JOURNAL OF THE

SMPTE

83d SMPTE Convention April 21-25 Ambassador Hotel, Los Angeles

volume 67 • number 4 **Part I** **April 1958**

JOURNAL of the
SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

PUBLICATION OFFICE TWENTIETH AND NORTHAMPTON STREETS, EASTON, PA.

Editorial Office

55 West 42d St., New York 36, New York

Editor—VICTOR H. ALLEN

Advertising Manager—DENIS A. COURTNEY

• • •

Subscriptions to nonmembers, $12.50 a year; single copies, $2.00 for one-part issues, $2.50 for special two-part issues. A 10% discount is allowed to individual members and accredited agencies on orders for subscriptions and single copies. A list of priced and gratis publications is available. Order from the Society's Headquarters Office, 55 West 42nd St., New York 36.

• • •

THE SOCIETY is the growth of over forty years of achievement and leadership. Its members are engineers and technicians skilled in every branch of motion-picture film production and use, in television, and in the many related arts and sciences. Through the Society they are able to contribute effectively to the technical advance of their industry. The Society was founded in 1916 as the Society of Motion Picture Engineers and was renamed in 1950.

Membership in Sustaining, Active, Associate or Student grades is open to any interested person according to his qualifications. Information about membership, technical activities and standards and test films for the industry is available from Society Headquarters.

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

Headquarters Office: 55 West 42d St., New York 36, N.Y. Cables: Somopict Telephone: LOngacre 5-0172

Executive Secretary: CHARLES S. STODTER

Published monthly by the Society of Motion Picture and Television Engineers. Publication office 20th and Northampton Sts., Easton, Penna. Second-class mail privileges authorized at Easton, Penna. Printed by Mack Printing Company, Easton, Pa.

Journal of the Society of Motion Picture and Television Engineers

VOLUME 67 • NUMBER 4 • APRIL 1958

Symposium on Optical Instrumentation for Missile Testing

During the decade in which the Society has had an organized interest in the applications and development of high-speed photography, missile programs have been extended far beyond anything foreseen at the time the Committee on High-Speed Photography was first appointed. The demands of the Age of Space have brought about a greatly expanded concept of photography and its relation to military science, though photography is only a part of the mechanism of detecting and recording the visible and infrared spectrum perceived by optical instruments in this field.

Many problems encountered in this field are related to the sciences of astronomy and meteorology. The first papers of the group describe the atmospheric problem, basic theoretical approaches and prospective results of present programs. Other papers describe specific operations and equipment. Finally, we have the group discussion in which diverse specialists have sought one another's help. A very important part of the process of obtaining final film records is that of film processing. It is hoped that this phase as well as others will be given careful attention in future meetings of the Society.—*Sidney M. Lipton*, Program Topic Chairman.

Atmospheric Optics

By H. C. SCHEPLER

The factors affecting the visibility and photographability of distant objects through the atmosphere are described. The manner in which each factor deteriorates the visual or photographic image is explained in detail. Means are suggested for reducing the effect of these factors to a minimum in the photography of airborne test targets.

Two main problems in photographing airborne targets are: (1) how to obtain an airborne target image from which the angular position of the target with respect to the camera can be determined; and (2) how to obtain the attitude (roll, pitch and yaw) of the airborne target with respect to the camera location.

In tracking and photographing an airborne target, the photographer is primarily concerned with resolution and contrast in the film image of the airborne target with respect to its background. In most instances, the background is the sky. If the problem includes tracking the airborne target throughout all or a portion of its trajectory, the background will vary considerably with the elevation of the camera and the relationship between the airborne target and the camera with respect to the position of the sun. Thus, the atmosphere is the major limiting factor in obtaining the desired photograph.

Certain aspects of the problem concern receptors. Receptors fall into three categories: (1) visual — where the eye observes the distant airborne target through a telescope; (2) photographic — where a camera records the image of an airborne target; and (3) infrared — where an infrared receiver detects the airborne target.

These receptors are affected in varying degrees by the various image-deteriorating factors in the atmosphere. These factors operate on the working material which is the contrast at the airborne target between it and its background.

Atmospheric Refraction

We are familiar with the bending of light as it passes, for example, from air into glass. This is due to a difference in density of the air and the glass. Air itself is a media of variable density depending on the elevation above the earth, temperature, pressure and local air currents. Therefore, when light from an airborne object to the camera passes through air of variable density, a displacement occurs of the target image on the film due to the bending of the light. This results in an error in the angular position of the target with respect to

Presented on May 2, 1957, at the Society's Convention at Washington, D.C., by H. C. Schepler, Photo Optics Branch, Air Force Armament Center, Eglin Air Force Base, Fla.
(This paper was received on April 15, 1957.)

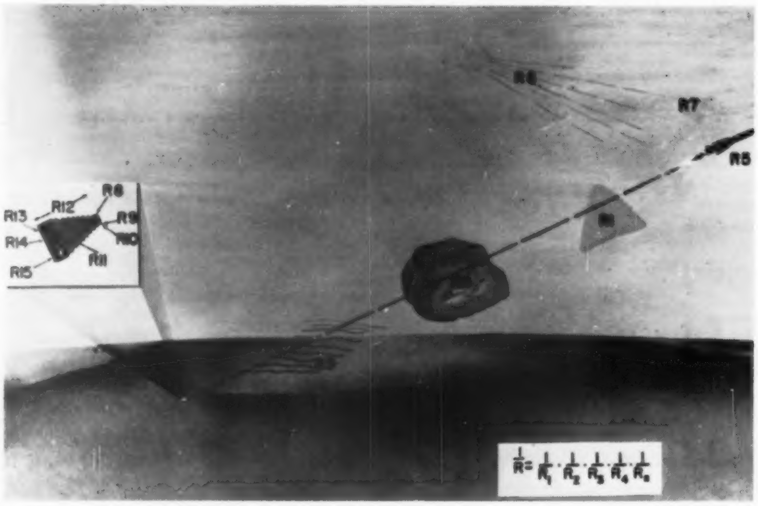


Fig. 1. Factors affecting photographic image.

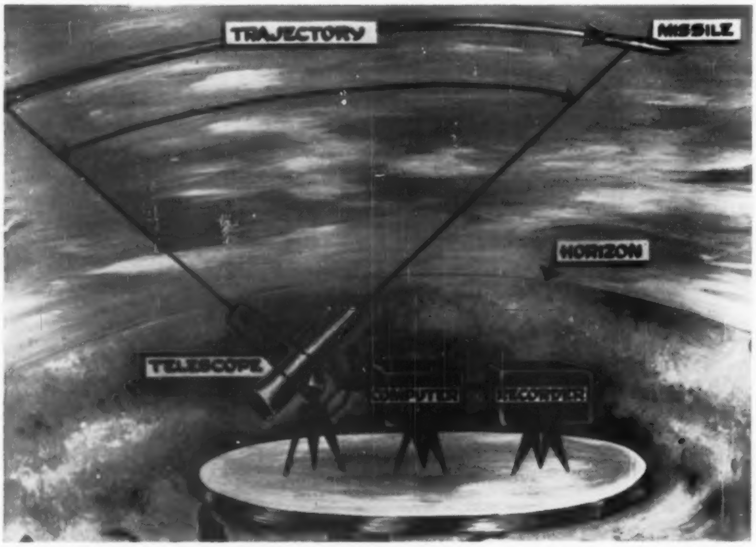


Fig. 2. Measurement of atmospheric visibility.

the camera. Only partial correction can be made for this error by using standard atmospheric refraction tables.

Haze

Small particles of water vapor, dust and other atmospheric impurities within a rather broad range of particle size will reflect, refract and absorb rays of light from the target which would normally enter the camera lens to form a photographic image of the target. Many extraneous rays from areas other than the target that are similarly reflected and refracted by these particles will enter the camera lens. Both of these occurrences reduce the contrast of the target image on the film with respect to its background image. The amount and the nature of such deterioration depend upon the types of particles, number of particles and particle sizes in the atmosphere between the target and the camera.

Another condition brought about by these particles is a loss of contrast due to the predominance of certain wavelengths of light entering the camera lens. Certain particles absorb and refract certain wavelengths more than others. A good analogy of this is the predominance of the color of red in the setting sun.

Shimmer

The appearance of a distant object viewed over a black-top road or a sandy beach in the heat of the summer sun shows a variable irregularity. This effect is a distant relative of atmospheric refraction in that it is caused by numerous air currents and bundles of air with varying densities and hence varying indices of refraction rising from the hot areas below. This condition further reduces contrast on the film due to the redirection of the light rays passing through such turbulent media.

Recent studies show that the greatest deterioration to the image on the film is due to the media or air near the camera. We can therefore somewhat reduce this deterioration by careful selection of camera location. The planting of green vegetation around the camera location for a radius of about a quarter of a mile can reduce shimmer effects considerably.

The seriousness of image deterioration on the film can best be appreciated by observing that all of the factors mentioned, plus many others, operate on the image simultaneously when photographing a distant airborne object.

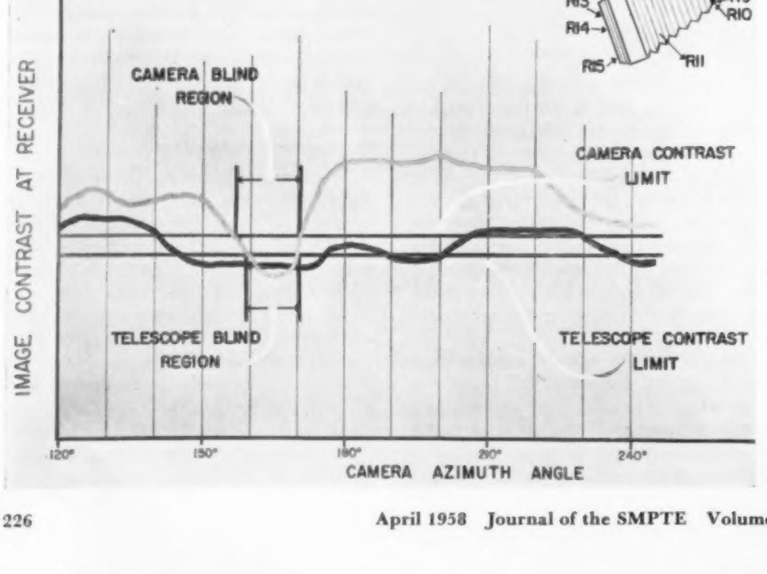


Fig. 3. Atmospheric visibility limitations.

In Fig. 1 the relationship is:

$$\frac{1}{R} = \frac{1}{R_1} \cdot \frac{1}{R_2} \cdot \frac{1}{R_3} \cdot \frac{1}{R_4} \cdot \frac{1}{R_n}$$

where R = the overall image deterioration,
R_1 = image deterioration due to atmospheric refraction,
R_2 = image deterioration due to haze,
R_3 = image deterioration due to shimmer, and
R_n = image deterioration due to causes other than the atmosphere.

Items contained in R_n are:

R_5 = color of airborne target,
R_6 = illumination of target,
R_7 = color of sky background,
R_8 = lens aberrations,
R_9 = lens distortion,
R_{10} = contrast factor of lens,
R_{11} = contrast factor of camera box,
R_{12} = focus of camera,
R_{13} = type of film,
R_{14} = film processing, and
R_{15} = film reading.

How instrumentation may make this accomplishment possible in the near future is indicated in Fig. 2. The anticipated missile or airborne target trajectory is scanned with a telescopic device that records the "contrast factor" for the anticipated trajectory. Two sample recordings are shown in Fig. 3. Also shown are the contrast limit of a camera and its sighting telescope. No signal is photographed or viewed below these respective lines. Blind regions for this particular camera and telescope are thus established; thus the practicality of running a mission under the prevailing atmospheric conditions is determined.

At such time that this instrumentation is constructed and found to be reliable, the time, effort and money now spent in obtaining test data on airborne targets will be considerably reduced. This instrumentation will also provide data sufficient to determine the physical limitations of camera lenses, that is, the physical lens sizes above which reliable and consistent photographic results cannot be obtained. With this information, instruments usable for a much higher percentage of time under adverse atmospheric conditions can be procured.

The various operating test ranges in the country are greatly concerned with these problems and have given them considerable study. Each range is concerned with analyzing the problem with the hope of finding some means of reducing the image deterioration effects of any one or all of these factors.

A related problem is that of prediction. If atmospheric conditions can be predicted in advance, considerable improvement in photographic results can be expected by the proper selection of photographic materials and equipment and of time for performing missions where photographic data are to be procured. At the present time methods of determining the nature of the atmosphere and of predicting the atmosphere in the near future are quite inadequate; however, there are good possibilities for constructing suitable instrumentation for accomplishing these purposes. It appears feasible to devise an instrument to measure the contrast of a target with respect to its background from the camera position. Knowing the color and luminance of the airborne target, the target contrast at the target can be determined with respect to its background. The contrast factor of the camera to be used can be measured. From these factors, the detectability of an airborne target can be determined by the eye, by film or by other means.

Discussion

S. M. Lipton (Session Chairman): Have there been any tests conducted at your installation, which would indicate the maximum diameter of optics which would give you good detail? This seems to be a paramount question for many.

Mr. Schepler: There have been many tests of this type, but I think this has been answered fairly well by the comments of Dr. Duntley and Mr. Martz, in that a 6-in. diameter lens is a good practical limit. This is as much information as we have on this problem. There are tests, of course, being continued on this subject and we undoubtedly will, as we go along, get additional information on it.

E. P. Martz, Jr. (Air Force Missile Development Center, N. M.): It may be interesting to note that since about 1890 there have been a large number of tests run by astronomers on this question of lens aperture and focal length, particularly aperture, as they affect astronomical seeing — shimmer-blur, haze — optical haze, whatever you want to call it. The same atmospheric refractive blurring has been studied, particularly at Lowell Observatory, and at other observatories. In general, where you want fine detail (such as, let's say — if I can use those nasty words — "*canals*" of Mars), or fine detail on the moon, or fine detail on the planets, an aperture of around 20 in. is an optimum. Above that, for night-time use, you normally run into too much atmospheric turbulence and you lose any gain of resolving power. Of course, this is the question Mr. Keene raised: where is the optimum gain? The loss of image quality and size of the image on the film begin to deteriorate compared to the increase in light or the increase in resolution you get from a larger lens.

Mr. Schepler: Around 20 in. for the astronomical problem is the case; 20 in. at $f/15$ is about what is normally operated. This might be taken as a guide for the missile work. There are, of course, large missile telescopic cameras under way, which other people could speak about if you wanted to go into this.

Visibility: Detection and Recording of Objects Against a Sky Background

By E. P. MARTZ, Jr.

The term "visibility" is used in reference to *detection* and optical-photographic *recording* of objects of small apparent angular size viewed through the atmosphere and against a day- or night-sky background. The factors influencing such detection and recording are discussed, including the relative luminance of the object by reflected sunlight or by artificial illumination, the attenuation by the intervening atmosphere, the luminance of the sky background due to scattered light, and the sensitivity and recording capabilities of the eye. Other influencing factors include photographic emulsions, other optical detectors and the optical imaging system. This paper undertakes to demonstrate that detection and recording are dependent upon the relative contrast between the object and the sky background and are directly comparable to the astronomical problem of photographing stars against a day- or night-sky background.

Two definitions of the term "visibility" are: (1) the condition, quality or degree of being seen, and (2) the condition of the atmosphere as affecting the distance at which objects can be seen and identified.

Knowles-Middleton (*Vision Through the Atmosphere*) has repeatedly pointed out the critical difference between *detection* and *recognition* of an object viewed through the atmosphere and the necessity for employing a criterion which refers to slant range distance of detectability of an object contrasted against the sky background rather than to any attempt at recognition or identification of the object. Such a criterion might better be referred to as the visual, optical, photographic or electronic *slant range detectability* rather than as the commonly misused term "visibility."

This paper is limited to the discussion of the detection and recording of relatively small objects both within and exterior to the atmosphere and at great distances from the observer. The apparent angular size of such objects, as seen by the observer, will be small and approaching the apparent point source size of stars or very distant lights. Objects which are very large or relatively close to the observer and have large apparent angular sizes, such as the moon or a large aircraft at a distance of a few thousand feet, present no particular problem of detection, recognition and visibility in an atmosphere of any clarity at all. However, when objects of cross sections up to several hundred square feet are to be observed and recorded at distances of tens to hundreds of miles, immediately a multitude of problems appear. Figure 1 shows the primary illumination, attenuation and instrumental factors involved.

Presented on May 2, 1957, at the Society's Convention at Washington, D.C., by E. P. Martz, Jr., Air Force Missile Development Center, Holloman AFB, N.M.
(This paper was first received on May 2, 1957.)

For the purpose of determining flight performance of high-altitude test vehicles, it is clear that there must be a permanent recording of the flight vs. time and not only a detection of the vehicle by visual observers. At the same time, visual or automatic detectors must pick up and home on the vehicle in flight in order to record it by photographic, photoelectric or electronic means. This implies that our detectors, whether human, optical or electronic have sufficient *sensitivity* to sense the object by the light coming from it and sufficient *selectivity* to distinguish it from the background illumination or "noise" of the sky against which it is seen. This immediately implies that detectability and recordability are a function of the relative illumination contrast between the object and its background, whether the object is a bright point (or a dark point) against a bright daylit sky or a bright point against a dark night sky.

Variables Affecting Visibility

Optical theory has been developed to explain the visibility of distant objects in terms of the obscuring characteristics of our atmosphere and the quality of the incident light, but when put to practical use in evaluating different types of light sources, illuminated objects, or other optical beacons, such theory has often been found to be inadequate. This is not because of any failure in our theory, or our optical beacons, but because of the very large number of variables which affect the visibility of any object viewed through the atmosphere under different conditions of solar illumination and the difficulty of measuring, comparing and evaluating these parameters to reach the desired quantitative conclusion. It is very nearly the same environmental problem experienced in electronic instrumentation but complicated, in the visual field, by the factors of the physiology and psychology of the human eye and brain, which are, perhaps, not yet so well understood as photoelectric cells, radar, microwaves and photographic emulsions.

During the day, test vehicles are visible by reflected sunlight, and by light reflected from clouds and from the

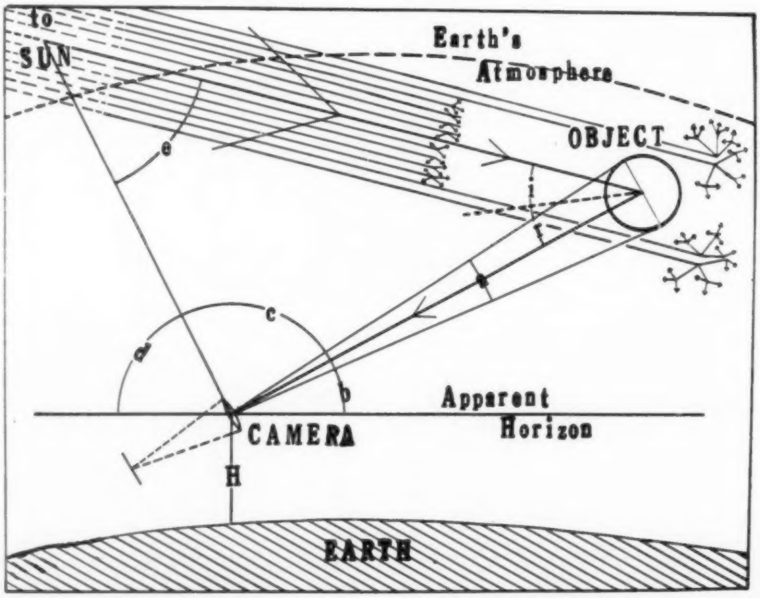


Fig. 1. Primary illumination, attenuation and instrumentation factors.

earth. Normally, these objects can be photographed only when the vehicle is at least 2% brighter, or darker, than the sky background on which they are superimposed. A safer figure is 10% difference in luminance. However, when the vehicle is closer to the observer, or much larger in size, it subtends a larger angular area in the sky and can be detected more easily even if its difference in brightness is less. At very great distances, and with small vehicles, the object usually appears only as a point and *must* have a considerable luminance against the sky to be detected and recorded.

A large vehicle, such as a V-2 rocket or a Moby Dick balloon, will reflect more sunlight to the observer, even when very far away, than will a small aircraft rocket a few feet long and under a foot in diameter. Thus, the larger object will appear brighter against the sky background even when it is a point source. Basically, this becomes the problem of seeing and photographing a point star image against the daylit-sky background.

At night, an artificial light source can be placed on the test vehicle to give the same type of star image. At night the naked eye, if the sky transparency is very good, can just about make out a star of 6th stellar magnitude by its contrast with the dark sky background. However, the night-sky background luminance is only about 22nd magnitude, or about $2\frac{1}{2}$ million times darker than the star.

During full daylight the sky background has a luminance of about 4th magnitude, about 16 million times brighter than the night sky. Therefore, the artificial star must be proportionately much brighter during the day to afford sufficient contrast against the sky background to make it visible. The planet Venus can, of course, be seen during the daytime when the observer knows where to look. At this phase Venus is about minus 4 magnitudes bright, compared to plus 4th magnitude for the sky background — a luminance difference of 1600 times. During the day, 3rd magnitude stars only $2\frac{1}{2}$ times brighter than the sky background are photographed with a medium-sized telescope and infrared film. However, factors of telescope aperture, focal length, and film sensitivity are critical and cannot always be applied to the operational cases experienced in practice.

The immediate concern is with small point source objects which are brighter than the day- or night-sky backgrounds. The use of an object darker than the daylit-sky background has some application to the cases where the object is very large or close to the observer and hence subtends a visible area in the sky. In this case, relative contrast is not the limiting factor. However, when the sky background is bright and the darker object is so small or so far away that it becomes an apparent point, the possibility of detecting or recording it becomes much less than for a point source which is brighter than the sky background. Considerations of optical instrumentation diffraction theory and the attenuating and light scattering characteristics of the earth's atmosphere lead to this conclusion. Exceptions such as telescopically observed transits of the small dark disks of Mercury and Venus across the bright face of the Sun and small black sunspots, are explainable on the basis of the parallelism of the background light of the solar disk.

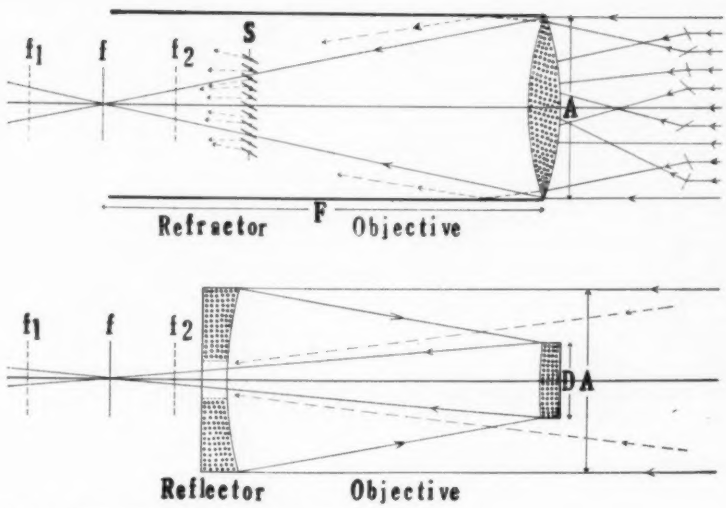


Fig. 2. Instrumental influence on image contrast.

Four Main Factors Influencing Contrast

Basic factors influencing the required contrast to detect and record a distant object are: (a) the relative luminance (or "brightness") of the object, (b) the relative luminance of the sky background during the day or the night, (c) the contrast rendition characteristics of the optical imaging system, and (d) the contrast rendition characteristics of the optical "sensor" or recording element.

Following is a detailed discussion of each of these four factors.

The relative luminance of an object *illuminated by sunlight*, as visible to the observer or recorder, is determined by:

(1) Intensity of the incident sunlight and skylight, allowing for loss due to atmospheric attenuation of the incident light.

(2) The size of the cross-sectional area of the object which is reflecting light and is visible to the observer as a "point source."

(3) The angles of incidence and reflection of sunlight on the visible surface of the object and including the effect of the shape of the object on these angles as influencing the appropriate reflection laws.

(4) Reflectivity and color of the surface of the object and whether it is a diffuse matte reflector or a specular reflecting mirror surface.

(5) Loss of reflected light due to atmospheric attenuation between the object and the observer.

For an object visible by an *artificial light source* carried with it (optical beacon) the relative luminance is determined by:

(1) Light output of the artificial light source.

(2) Directional emission of light from the artificial source with respect to the observer or recorder.

The luminance of the sky background *in daylight* is influenced by:

(1) The amount of gaseous molecular haze and other particles (dust) scattering and absorbing incident light from the Sun.

(2) The apparent angular height of the object above the horizon with respect to the atmospheric path length encountered.

(3) The angular distance of the object from the Sun.

(4) The angular height of the Sun above the horizon.

(5) The altitude of the observing station above the atmospheric haze layers.

Luminance of the *night sky* is influenced by:

(1) The amount of atmospheric haze present to scatter light.

(2) The amount and nature of secondary illumination present due to surrounding lights, aurorae, "light-of-the-night-sky," etc.

Figure 2 illustrates the contrast rendition characteristics of optical imaging systems which are limited by:

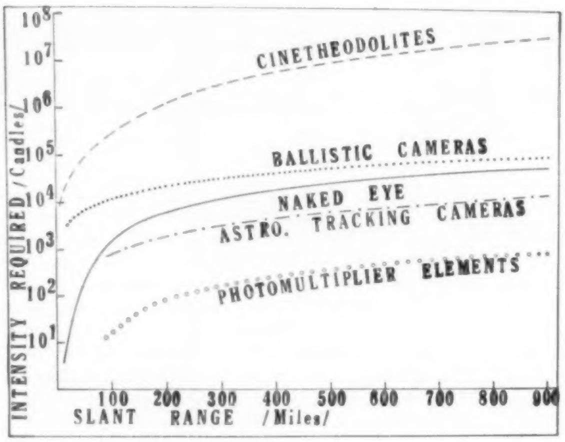


Fig. 3. Optical beacons used on test vehicles.

(1) The aperture of the telescopic-photographic objective.

(2) The focal length of the objective, relative to the aperture.

(3) The character of the optical diffraction image as determined by aperture, focal length, and any obstructions such as secondary central mirrors in reflecting objectives and louvre or "venetian blind" type camera shutters.

(4) Stray and scattered light in the optical system.

(5) Image blurring and "dilution" of the light intensity per unit area on the film plane due to tracking error during the exposure time.

(6) Image blurring and intensity "dilution" due to irregular, small scale atmospheric refraction during exposure and including such effects due to internal air turbulence within the optical system as well as refraction exterior to the camera. ("Astronomical Seeing"—the term applied by astronomers to this small-scale atmospheric refraction blurring the image.)

(7) Image blurring and intensity "dilution" arising from poor focus due to error, thermal effects on optical element mountings, change of object distance, "supplementary lensing" by atmospheric refraction, etc.

(8) Image "dilution" due to poor correction of the optical system for chromatic, spherical and other aberrations.

Optical sensors and detectors include the human eye, photographic emulsions and photoelectric and infrared sensing elements and image tubes.

The *human eye* is limited by:

(1) The sensitivity of the rods and cones of the retina.

(2) Dependence upon dark or light adapted state of the eye.

(3) Dependence upon angular size and shape of stimulus on retina.

(4) Dependence upon sharpness of boundary of the stimulus.

(5) Dependence upon color sensitivity of the eye and color of light from the object (light adapted, 5550 A.; dark adapted, 5150 A).

(6) Dependence upon the presence of disturbing stimuli in the field.

(7) Dependence upon the time duration of flash stimuli.

(8) Turbidity of the eye medium.

Limitations of *photographic emulsions* include:

(1) Dependence upon sensitivity, or "inertia," or "threshold" values.

(2) Limited by the slope of the characteristic curve (gamma).

(3) Limited by graininess and granularity and by the size of the optical image of the object on the film (plus turbidity).

Photoelectric and infrared sensing elements and image tubes are:

(1) Limited in sensitivity by detector threshold and by the electronic amplification possible.

(2) Limited in contrast by degree of "noise" background present with the amplification used.

(3) Limited by size of detector elements or by granularity of image tube screens.

These factors demonstrate clearly the complexity of the problem of detection and recording of distant objects. An additional factor, implied in the listing, is the detrimental effect of the earth's atmosphere in absorbing and scattering light and reducing the amount reaching the eye or camera from the object and hence reducing the contrast between it and the sky background and decreasing the range of detectability. Clearly, this becomes rapidly worse as the vehicle gets farther away, both because of the exponential depletion of light as the atmospheric path length is increased, and because of the fall-off of illumination from the point-source vehicle inversely as the square of the distance.

Fortunately, by use of optical beacons on the test vehicles their brightness as "stars" can be sufficiently increased to make them visible even during daylight; although, admittedly, the problem of optical-photographic detection and recording with such optical beacons is much simpler against the night-sky background (Fig. 3).

Optical Beacons

Such "optical beacons" include anything which makes a larger area for reflection of sunlight, such as chemical smokes or ejected plastic balloons, devices which increase the per-unit-area reflectance of sunlight from the vehicle, such as white and fluorescent paints and corner reflectors, and self-contained light sources such as chemical flares, flash bombs, photoflash bulbs, and electronic gaseous discharge flash tubes. Such optical beacons are directly comparable to electronic radar and other beacons used for the same purposes. As previously noted, if the vehicle and its optical beacon are far enough away from the observer they become point star light sources. A distant white smoke trail can be considered as merely a collection of individual point star images spread out in a line. There is one point in favor of such smoke trails which is that the human eye can detect a thin line seen against a fainter background more easily than it can detect a single point star image of the same luminance. However, for accurate measurement of position on a photographic film, the point image is much preferable.

As previously noted, if the vehicle is either close enough or large enough to present a visible area against the sky to the observer, it does not need to have as much increased luminance and contrast as when it is a single point star source. For example, the surface of the moon is a relatively poor reflector of sunlight (5% to 10%), but it is often visible clearly in full daylight, due to its large apparent area. A section of it small enough to appear as a single point could not be seen at all during the daytime against the bright sky background by the naked eye.

Figure 3 shows schematically the intensity in candlepower required of vehicle-borne optical beacons to be seen as point source stars, and to be recorded at night extrapolated to slant range distances up to 900 miles. The absorption and scattering effects of the earth's atmosphere have been included here, in addition to the inverse square loss of intensity with distance, and the optical detection characteristics of the human eye, the photographic emulsion, and the photoelectric element. The effect of camera shutter exposure times with motion of the vehicle image on the film

during exposure have also been included in terms of the intensity-per-unit-area "dilution" effect. The curves for astronomical-type tracking on the vehicle for long exposure times and for photomultiplier-type detectors have been included only to demonstrate their relative positions. The other curves have been derived from observational data and accepted visibility theory.

This figure is for detection and recording against a night-sky background. During the daytime, all of the curves would have to be raised by a factor of perhaps 10^4 to counteract the "noise" of the daylit-sky background in reducing the relative contrast between the image of the optical beacon and the sky. Narrowband color filters, infrared light, and other techniques will aid greatly in reducing this "noise" without increase in output of the beacon.

Discussion

George T. Keene (Eastman Kodak Co., Rochester, N.Y.): In this case, where you are talking of point sources as opposed to sources of finite area, wouldn't it be desirable to have as large an aperture as possible, since you are seeking only to record a faint object rather than to detect image detail in a small object?

Mr. Martz: The answer is "yes," and the larger the aperture the worse the blurring. This has been well established. We spent a whole day at Peterboro discussing it, if you remember, last summer — and that the larger aperture gives you a more blurred image — therefore you have the light distributed over a larger area on the film, therefore the light per unit area is less on the film and you need a brighter light source, so you have an optimum point in there between gaining light in the optical system with a larger aperture and losing light in the film plane due to the image blurring. Under different atmospheric conditions, the optimum aperture will differ.

Mr. Keene: Probably in this situation, though, the optimum aperture is somewhat larger than when you're actually trying to see detail?

Mr. Martz: Yes, for the purpose of gaining light for a faint, distant point source, you would be able to use a larger aperture to get high sensitivity. You can't draw a line and say it's always 10 in. or 5 in. — or anything else — it depends entirely upon the local atmospheric conditions at the time of observation, and the optical lever arm effect of the focal length.

Atmospheric Limitations on Missile Photography

By SEIBERT Q. DUNTLEY

Optical data taken from an aircraft in flight as well as data secured at ground level have enabled the obscuration of high-flying missiles by the atmosphere to be ascertained and the requirements to be met by telescopic finders and cameras to be specified for several typical weather and lighting conditions.

MISSILE photography encounters atmospheric limitations whenever the object-to-camera distance is long. This paper is concerned primarily with the long-range case. If missile photography were conducted in the absence of deleterious effects due to the atmosphere, sufficiently large high-quality optics and sufficiently accurate mountings would enable any required level of detail to be resolved in the resulting photographs. The atmosphere, however, sets a fundamental limit on resolution, and this limitation comes about in two ways. First, the atmosphere scatters light in such a manner as to lower the apparent contrast of the distant objects and cause them to merge with their background. Second, the atmosphere contains refractive imperfections which may obscure fine detail in somewhat the same way that ripples on the surface of a pond obscure small stones on the bottom.

Because the atmosphere is usually in motion, the presence of these refractive imperfections, due primarily to small-scale variations in temperature, often exhibit a dynamic manifestation called *shimmer* or *boil;* thus stars are seen to twinkle and extended objects to distort and appear blurred. All who have used telescopes are acquainted with the fact that the effects of atmospheric boil are more pronounced and more serious as magnification is increased. Exactly the same situation occurs in long-lens photography. Atmosphere which exhibits no shimmer effect which can be discerned by the naked eye or by ordinary cameras may cause distant objects to appear as a swirling blur in pictures taken with missile-tracking cameras having focal lengths of several hundred inches. No discussion of the limitations imposed by the atmosphere on missile photography would be complete without consideration of both the effects due to atmospheric scattering and those due to atmospheric boil.

Atmospheric Scattering

In the absence of effects due to atmospheric boil, the apparent luminance of any distant object seen through the atmosphere is the sum of two independent components: (1) residual image-forming light originating at the object and traversing the intermediate space without experiencing scattering or absorption; (2) luminance generated by scattering processes throughout the path of sight, including contributions due to scattered sunlight, sky light, earth shine, etc. The second of these components contains no information concerning the object but serves only to mask it by lowering the contrast available to the camera. At sufficiently low levels of contrast, details cannot be resolved.

A quantitative description of contrast reduction due to scattering within the atmosphere is given by Equation (1).*

$$\frac{B_{missile}}{B_{sky}} = 1 + T \left[\frac{B'_{missile}}{B_{sky}} - \frac{B'_{sky}}{B_{sky}} \right]$$

It states that the apparent contrast-ratio of a missile as photographed from the ground is given by unity plus the transmittance of the atmospheric path between the missile and the camera multiplied by a factor composed of two terms: the first of these is the ratio of the inherent luminance of the missile to the apparent luminance of the sky as seen by the camera; and the second term, which enters by subtraction from the first, is the ratio of the luminance of the sky above the missile in the direction of the path of sight to the apparent luminance of the sky as seen by the camera.

In Eq. (1) the primed luminances are to be thought of as measured by a photometer located close to the missile, whereas luminances without the prime

A contribution from the Scripps Institution of Oceanography, New Series No. 1000, presented on May 2, 1957, at the Society's Convention at Washington, D.C., by Seibert Q. Duntley, Visibility Laboratory, Scripps Institution of Oceanography, Univ. of Calif., San Diego 52, Calif., and received in written form on June 19, 1957. This paper represents results of research which has been supported by the Bureau of Ships, U.S. Navy.

*For derivation, see Equation (6) of S. Q. Duntley, A. R. Boileau and R. W. Preisendorfer, "Image transmission by the troposphere," *J. Opt. Soc. Am., 47:* 499–506, 1957.

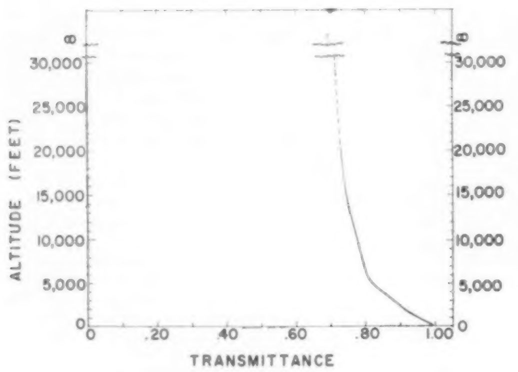


Fig. 1. Transmittance of the atmosphere for image-forming rays along a vertical path of sight from any altitude to the ground on a typical clear day. The solid portion of the curve is based upon experimental data; the dotted portion is an extrapolation based upon a standard atmosphere.

are as measured at the camera; all luminances are measured in the direction in which the camera is aimed; T is the transmittance of the atmospheric path from missile to camera for image-forming rays. Strictly, Eq. (1) should be written in terms of monochromatic radiance N, rather than in terms of luminance B, because all of the radiometric quantities are functions of wavelength. The flight research which has been conducted by the Visibility Laboratory at the University of California has demonstrated, however, that under virtually all circumstances the scattering processes in the atmosphere are sufficiently nonselective so that the equation can be used within the precision requirements of missile photography either with luminance (B) or with data obtained by means of a photometer having the same spectral sensitivity as the missile-tracking camera. There is, therefore, a practical right to use the equation in the form in which it is written.

In the case of a high-flying missile the luminance of the sky above it may be so small compared to the luminance of the sky as seen from the ground that the second term of Eq. (1) is negligible.

Equation (1) is the only expression necessary for a quantitative description of the reduction of contrast caused by atmospheric scattering along any upward-looking path of sight. It must, however, be supplied with experimentally measured data. For this reason the Visibility Laboratory has been engaged for some time in an extensive flight research program aimed at providing the data required for the practical utilization of this equation. As an example of such data, Fig. 1 shows transmittance versus altitude for an observer looking vertically upward on a typical clear day. Thus the transmittance of a vertical path of sight from an object at 20,000 ft to a camera located at sea level is read from this graph as 0.73. If the path of sight is not vertically upward but at some zenith angle θ, then the transmittance of the path from the camera to the 20,000-ft elevation will be 0.73 raised to the secant θ power. Thus, when photographing a missile which is flying at 20,000 ft, but which appears to be 10° above the horizon (zenith angle = 80°), the path transmittance is 0.73 raised to the 5.76 power or 0.16. If the camera has its back to the sun, the sky in the direction of the object will appear to have a luminance of 2,100 ft-L. A photometer just above the missile directed upward in the direction of the line of sight would measure a luminance of 1,400 ft-L. The missile, if painted white, might have a luminance of 8,400 ft-L. When these numbers are substituted in Eq. (1) it will be found that the apparent contrast ratio at the camera will be 1.53, i.e., $1.53 = 1 + 0.16 \left[\frac{8400}{2100} - \frac{1400}{2100}\right]$.

It is obvious that sky luminance data are required for the use of Eq. (1). There are a number of sources of applicable information in the public literature.[1] Scientists who have taken photometers to high altitudes in balloons report that the luminance of the sky is approximately proportional to atmospheric pressure. Thus, tables such as those of Packer and Lock, which relate to the luminance of the sky in the neighborhood of 35,000 ft, can be extrapolated upward or downward by means of pressure ratios. The principal uncertainty in this process arises from the possible existence of layers of tenuous high altitude clouds which are difficult or impossible to see from the ground but which affect sky luminance.

Fortunately, the only requirement for knowing the sky luminance at high altitude is set by the second term of the equation, and this term becomes progressively less important as the missile goes higher. Since the second term is often small and can be regarded merely as a correction to the first term, it usually suffices to use tabulated high-altitude sky luminance data for this correction.

Under marginal atmospheric conditions, it sometimes develops that photography is successful although visual tracking fails; or, alternatively, under some circumstances the missile can be followed through the telescopic finder but the camera records nothing. Advance information concerning the probability of success in the photographic and visual tracking of the missile is obviously desirable. This information can be calculated from the known properties of photographic equipment and of the human eye provided the apparent contrast of the missile is known. Equation (1) provides a basis for obtaining this required information. The techniques for such calculations are well known. A typical result is illustrated by Fig. 2. This is a plot of magnifying power of a telescopic finder required to track a certain missile on a typical low-altitude flight. The required magnification is plotted as the function of the azimuth toward which the camera is pointed during the process of tracking the missile. In the case illustrated, it will be observed that more than 35-power is required in order to track the missile throughout the entire path. A 30-power tracking telescope will be able to follow it throughout the section of the path lying between azimuth 25° and 60°, and it can be found again at azimuth 91° and tracked to azimuth 101°. A telescope of lesser power will, of course, provide coverage through a lesser part of the path. For example, a 20-power telescope will track the sectors shown by the heavy line, and a 10-power telescope will enable the missile to be seen only in a region between azimuth 32° and azimuth 42°.

Atmospheric Boil

Ordinarily the missile subtends from the camera an angle larger, by far, than the root-mean-square (rms) random deviation of image-forming rays by atmospheric refractive processes. Missile photographers, on the other hand, are seldom content to have the image appear as a shapeless dot in the film. They desire to resolve details such as control fins and other structures. These subtend very much smaller angles at the camera, and these angles, fractions of seconds of arc, often correspond in size with the rms ray deviations due to boil. In such cases atmospheric boil limits the ability of cameras to record these details even though the focal length of the camera and the resolving power of the film are sufficient to provide adequate resolution if the atmosphere were free from refractive imperfections. The cameras in use at the missile test centers usually fulfill this basic resolution requirement; it is often the shimmer-state of the atmosphere that sets the resolution limit.

Apparatus has been devised that enables the rms deviation of image-forming rays due to boil to be measured from the camera station. It is found that rms ray deviations of a few tenths of a second of arc are commonly observed for near-vertical paths of sight and that values up to several seconds of arc typify near-horizontal paths.

The rms ray deviation depends upon the diameter of the entrance pupil (lens diameter) of the camera and upon shutter speed. Typical data are shown by

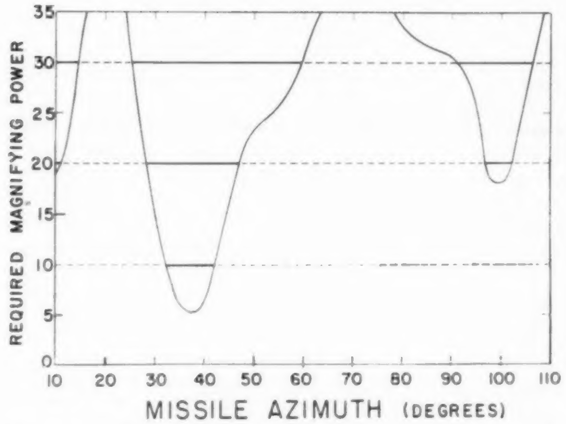


Fig. 2. Magnifying power required to enable a typical missile to be tracked visually by means of the telescopic finder on a missile camera.

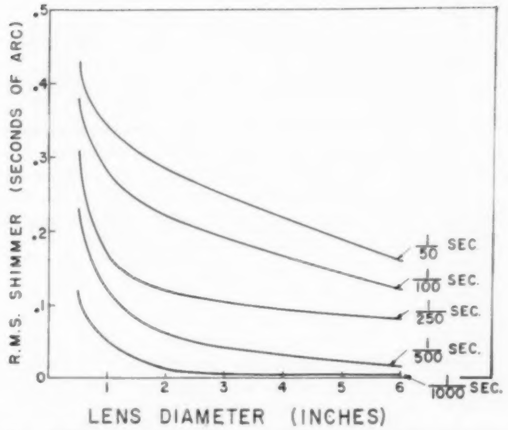


Fig. 3. Illustrating the dependence of rms shimmer upon lens diameter and shutter speed for a nearly vertical path of sight on a typical clear day.

Fig. 3. The effective rms shimmer can be markedly reduced by using the optimum aperture and a fast shutter.

A theoretical equation by means of which the rms ray deviation may be interpreted in terms of contrast loss for any item of fine detail has been published.[2] This equation is repeated here as Eq. (2).

$$\left[\frac{\bar{B}_{\text{missile}}}{B_{\text{sky}}}-1\right]=\left[\frac{B_{\text{missile}}}{B_{\text{sky}}}-1\right]\left[1-e^{-\frac{1}{2}\left(\frac{\psi}{\sigma}\right)^2}\right]$$

In Eq. (2) the contrast ratio $B_{\text{missile}}/B_{\text{sky}}$ has the same significance as in Eq. (1); i.e., the ratio of missile luminance to sky luminance at the camera without regard to contrast degradation due to atmospheric boil. The contrast ratio $\bar{B}_{\text{missile}}/B_{\text{sky}}$ in Eq. (2) is the corresponding ratio at the camera but including the effect of boil. The symbol ψ represents the apparent angular radius of the object, assumed circular, and σ is the root-mean-square ray deviation characteristic of the path of sight, the lens diameter, and the shutter speed. This equation is a sufficient geometrical approximation for most practical problems in missile photography.

The reduction of contrast is seen to be controlled by the ratio of ψ to σ. When these two angles are roughly equal, the contrast loss due to shimmer becomes important. The relation is illustrated by Table I. Thus, if the rms shimmer is half

Table I

ψ/σ	$[1 - e^{-\frac{1}{2}(\psi/\sigma)^2}]$
3	0.99
2	0.86
1	0.39
½	0.12
⅓	0.05

a second of arc, details subtending half a second of arc will be reduced in their contrast to the order of 40% of the contrast which they would have if there were no refractive imperfections in the atmospheric path. The dependence upon the angular size of the target is quite sharp. Objects subtending angular radii three times greater than the rms shimmer have their contrast essentially unaffected, details whose angular radii are one-third the rms shimmer are wiped out entirely. By virtue of these rules-of-thumb, it is seldom necessary to use the equation.

References

1. D. M. Packer and C. Lock, "The brightness and polarization of the daylight sky at altitudes of 18,000 to 38,000 feet above sea level," *J. Opt. Soc. Am., 41:* 473–478, July 1951.
2. S. Q. Duntley, W. H. Culver, F. R. Culver and R. W. Priesendorfer, *J. Opt. Soc. Am., 42:* 877A, Nov. 1952.

Discussion

Floyd Kinder (*Naval Ordnance Test Station, China Lake, Calif.*): You commented that you needed larger lenses as well as faster shutter speeds. Might not the larger lenses take in more "boil" area? Or what effect might there be?

Dr. Duntley: The plot I showed went up to 6 in. in diameter because my experiments were made with a 6-in. diameter lens. I have tests scheduled next week for an optical system of larger diameter, but right now I don't know if there is a deterioration of quality at larger apertures. It may depend on geographical location and circumstance; what really counts, I think, is the relation between the size of the optics and the size of the turbulent parcels in the atmosphere.

Flying Camera Stations

By FLOYD A. KINDER

This type of instrumentation is based upon the principle of determining aircraft positions and attitude by photographing surveyed ground markers with one aerial camera. To obtain attitude, trajectory and documentary data of missiles launched from aircraft at high altitudes an Airborne Cinetheodolite based upon this principle has been proposed. Factors affecting the accuracy are presented.

The concept of a flying camera station is based upon the principle of determining aircraft attitude and position by photographing surveyed ground markers (Fig. 1). The advantage of this method is that a complete solution is obtained from one photograph, without recourse to ground instrumentation. Although various applications using analog data-reduction methods have been in use for some time, only recently have satisfactory analytical solutions been made possible — a situation resulting chiefly from the advent of high-speed electronic computers.

Basic Solution

The analytical solution in use at the Naval Ordnance Test Station is a combination of various solutions* incorporated into one program for the IBM 701 Computer. This program first makes preliminary corrections for lens distortion, film shrinkage and rotation of the film when read in the computer. The X, Y, Z camera position is then determined from four markers that are assumed to be at the same elevation. An iterative solution is used to correct for variation in elevation between the ground markers and for atmospheric refraction until the successive changes in the X, Y, Z position are negligible. The attitude is then computed. From this position-and-attitude determination a least-squares solution, which uses up to 18 ground markers per film frame, recomputes the position and attitude and indicates the accuracy of the completed solution from the residuals. This program also has an additional feature which computes the film-reading accuracy and eliminates any marker readings exceeding a set variance before recomputing both position and attitude.

The solution can be considered a ratio-type problem, with the rear node of the lens separating the interior and exterior orientation. The interior orientation is determined by the calibrated focal length and the location of the principal point. Errors in interior orientation could be caused by (1) changes in focal length, (2) lens distortion, (3) film shrinkage and emulsion creep and (4) movement of fiducial marks. Since the accuracy of the solution depends on the cone of rays from the rear node to the film plate having the same angular relationships as the cone of rays from the ground to the rear node, a camera with a rigid inner orientation is required.

Several cartographic-type cameras (developed for mapping) have an inner structure that keeps the lens rigid with respect to the focal plane, as well as a between-the-lens shutter and a lens calibrated for distortion. In a calibrated cartographic plate-camera, the net inner orientation error can be held to around 0.01 mm on the film plane, which gives an idea of the magnitude of errors permitted in the exterior orientation. For example, a displacement of 0.01 mm on the film plane of a camera with a 6-in. effective-focal-length lens at 10,000 ft is equivalent to 0.7 ft on the ground. This means that in flights below 10,000 ft, the survey would need to be at least second-order if the survey errors were to be smaller by one magnitude than the camera errors.

Another factor to consider in the exterior orientation is the configuration of the markers themselves. The ideal would be to have the four principal markers at the corners of the field-of-view of a 90° lens in order to have a good triangulation angle. Considerable variation from this ideal can be allowed without unduly affecting the accuracy, as can be seen from the typical examples in Fig. 2. This factor probably accounts for most of the variation in standard deviation, if the film reading accuracy has been constant.

Presented on May 2, 1957, at the Society's Convention at Washington, D.C., by Floyd A. Kinder, Test Dept., U.S. Naval Ordnance Test Station, China Lake, Calif.

(This paper was received on May 2, 1957.)

* Otto Neall Strand, "Mathematical methods used to determine the position and attitude of an aerial camera," (NAVORD Report 5333, NOTS 1585), unclassified, NOTS, March 1956.

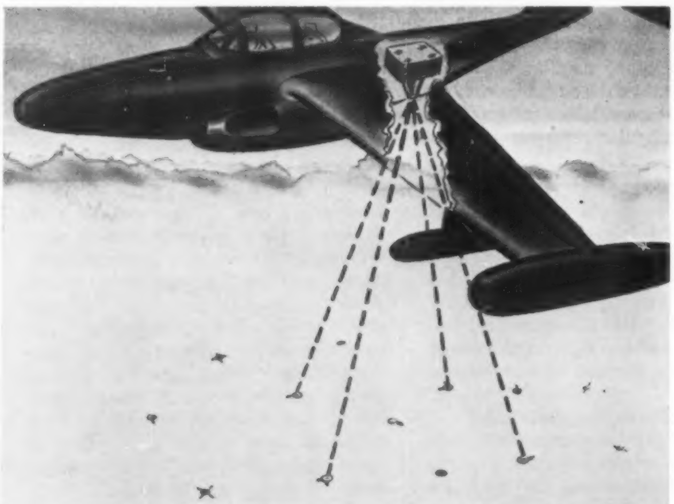


Fig. 1. Basic aerial camera instrumentation for determining position and attitude of an aerial camera by photographing surveyed ground markers. (Official U.S. Navy Photo)

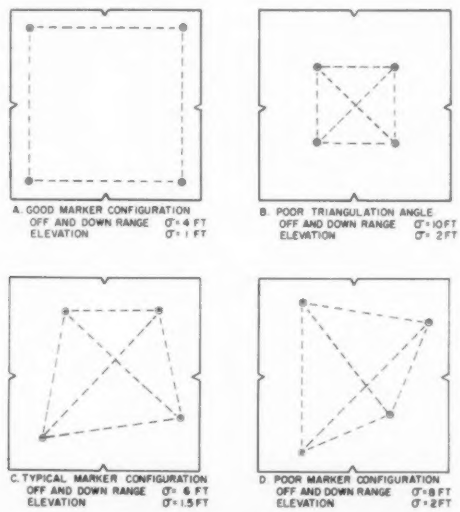


Fig. 2. Typical effect of marker configuration on standard deviation of position. Test made at 15,000-ft altitude using RC-7 camera with 60° field-of-view.

The total effect of both internal and external (atmospheric refraction) orientation errors and poor marker configuration is to reduce the accuracy of the solution. The least-squares solution reduces only the effect of random errors. Any bias in the camera calibration or in other corrections results in a constant bias in the answer.

Test Results

Flight tests to evaluate the accuracy of the solution were made, using an RC-7 automatic plate-camera. This involved four flights at two different altitudes while using the same ground markers. Two of the flights were made at 10,000 ft with a 4-in. Aviogon lens (90° field-of-view), and two at 15,000 ft with a 6-in. Aviotar lens (60° field-of-view).

While the RC-7 aerial camera was photographing the ground markers, six Askania cinetheodolites were photographing the aircraft from the ground. The time of operation of the aerial camera and Askanias was transmitted by radio link and recorded on an oscillograph. As the aerial camera was not synchronized with the Askanias, the position data were interpolated. If the airplane were moving at other than a linear rate in a constant direction, this would be a source of additional error. Figures 3 and 4 show the test results. The center lines, representing the airplane position points as determined by the Askanias, are the standard, while the plotted points are the positions as obtained with the RC-7 aerial camera.

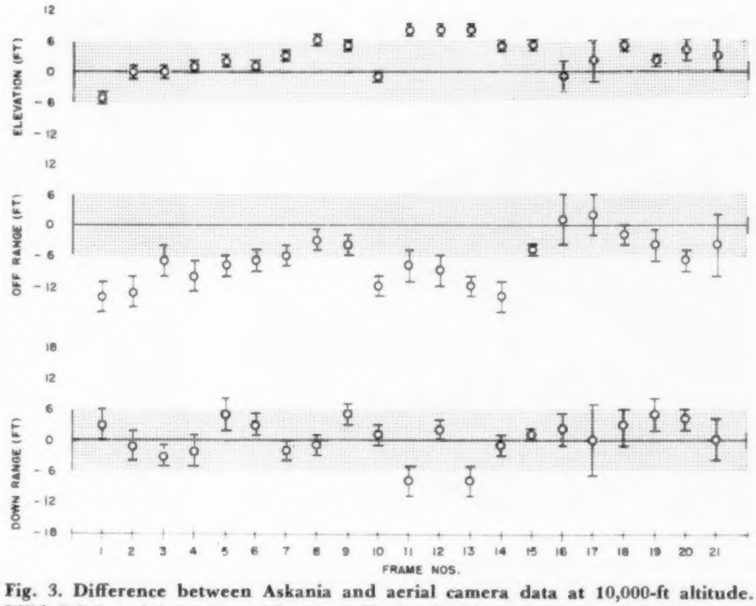


Fig. 3. Difference between Askania and aerial camera data at 10,000-ft altitude. Wild RC-7 aerial camera with 4-in. effective-focal-length lens, 90° field-of-view. ⌽ = RC-7 data, the bars indicating its standard deviation. Shaded area is standard Askania deviation.

These results agree favorably with the accuracy expected from residuals of the RC-7 least-squares solution standard deviation computation. The average standard deviation of the RC-7, using the 4-in. lens (90° field-of-view), was approximately three feet in off-range and down-range and one foot in elevation, which was half the standard deviation when the 6-in. lens (60° field-of-view) was used. Part of the larger standard deviation of the 6-in. lens was due to the increased height — 15,000 ft compared to 10,000 ft — using the 4-in. lens, and the rest was probably due to the smaller triangulation angle.

Tests with a T-11 cartographic film camera, having a 6-in. lens and 90° field-of-view, under the same conditions had approximately the same standard

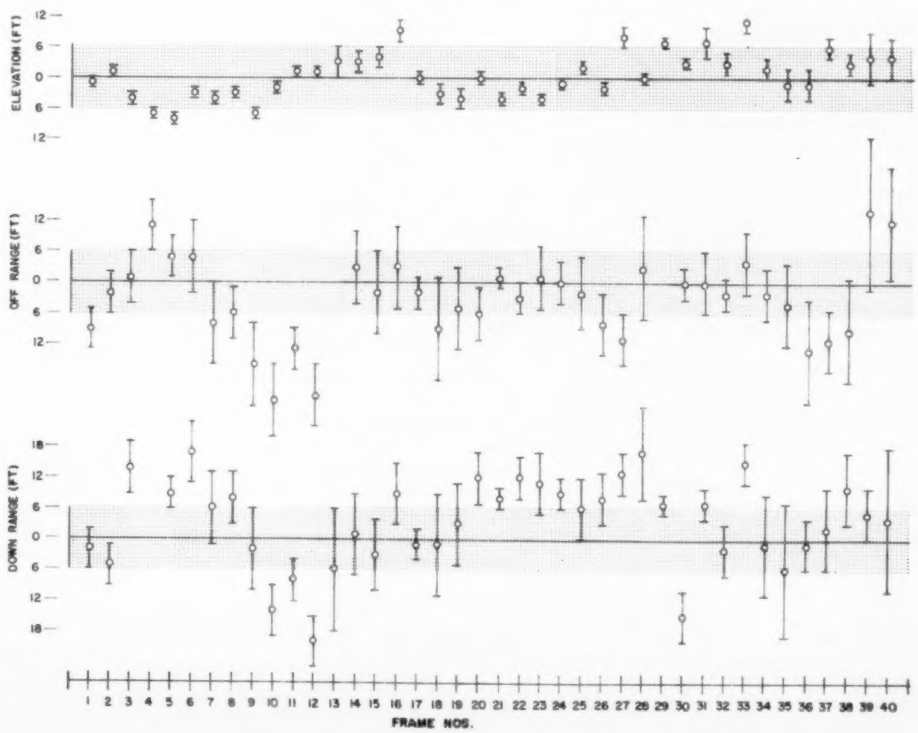


Fig. 4. Difference between Askania and aerial camera data at 15,000-ft altitude. Wild RC-7 aerial camera with 6-in. effective-focal-length lens, 90° field-of-view. ⌽ = aerial camera data. Bars indicate standard deviation. Shaded area is standard Askania deviation.

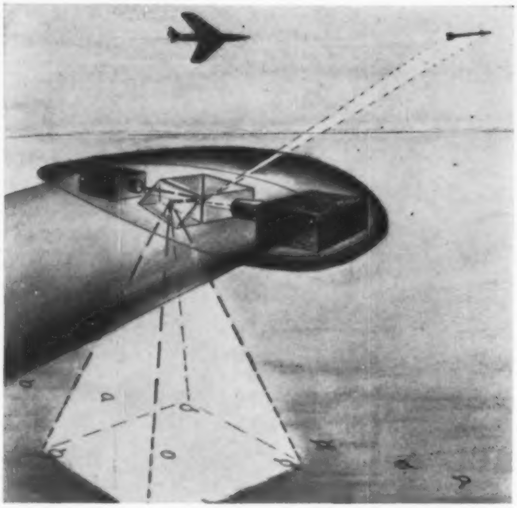


Fig. 5. Principle of airborne cinetheodolite: The angle from the tracking camera to the missile is determined by the other camera photographing the ground markers through a common tracking mirror. (Official U.S. Navy Photo)

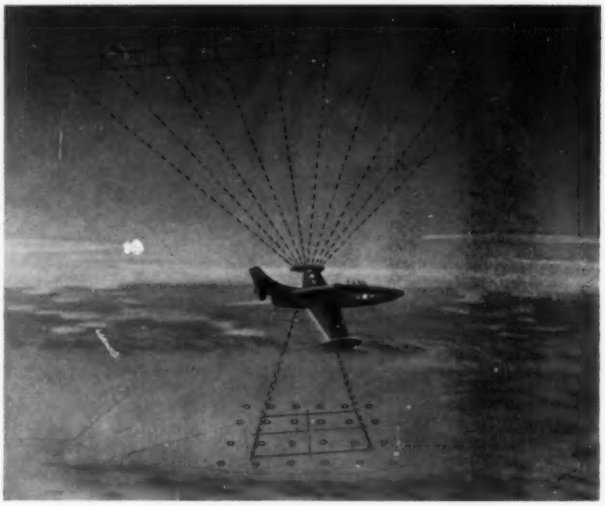


Fig. 6. Flying camera station carrying bank of fixed cameras in wing or belly pod to obtain missile attitude and trajectory data. Position and attitude of flying camera station are determined by an aerial camera photographing surveyed ground markers. (Official U.S. Navy Photo)

deviation as obtained with the RC-7 plate-camera using the 4-in. lens. The least-squares solution reduces the effect of the larger random errors in film, thus achieving almost the same accuracy as obtainable with plates, for the same accuracy in measurement. As the film is larger — 9 by 9-in., compared with $5\frac{1}{2}$ by $5\frac{1}{2}$-in. plates — the residual errors do not have as great effect upon the solution because of the increased scale.

Attitude Accuracy

Methods now being used to determine aircraft attitude are not nearly accurate enough for use in checking this method. The standard deviations in attitude obtained in the above test were all close in accuracy to 1 min. of arc, which is much better than the attitude accuracy obtainable with ground cameras. The high accuracy of this method of determining attitude, together with the simplicity of operations, should meet most aircraft flight-test and instrument check requirements of this type.

Applications of Flying Camera Station

Aircraft Orientation: The first use for this method has been the determination of position and attitude of the airplane carrying the camera. Such information is needed in bombing tests, and in determination of rate of roll and measurement of the stall angle of the airplane, etc. For most tests, especially in jet aircraft, the camera can be fastened rigidly to the airframe if fast shutter speeds (1/500-sec or better) are used.

Airborne Cinetheodolite: Another use for this type of instrumentation has been proposed for solving the problem of obtaining attitude and roll data of air-launched missiles at high altitudes. Because of the long slant ranges required if ground-based instruments are used, it is often impossible to obtain attitude information and difficult to even record some of the images because of the limiting effect of atmospheric turbulence. To rectify this it is planned to build an airborne cinetheodolite based on the principle of determining position and attitude with a single aerial camera. Two 70mm cameras would be mounted in a pod facing each other (Fig. 5), with a tracking mirror mounted between them. One camera would have a long-focal-length lens for tracking the missile, while the other camera would have a short-focal-length wide-angle lens for photographing the ground markers, from which the attitude angles would be obtained in place of the conventional scales of a theodolite.

The primary error in determining the trajectory of the missile will be in the position determination of the airborne cinetheodolite, since the error between missile and cinetheodolite would only be two or three feet because of the shorter distance involved. The RC-7 test has indicated that the position of the cinetheodolite could be determined to approximately ± 20 ft at 40,000-ft elevation, so the position of the missile as determined by two flying camera stations should be accurate to approximately ± 30 ft. This means that the velocity data would be rather poor, as can be seen from the following computation:

A missile traveling at 2,000 fps, and having its position determined 10 times a second, travels 200 ft between frames. The velocity then equals:

$$V = \frac{d \pm \Delta d}{t}$$

or

$$\Delta V = \frac{\Delta d\sqrt{2}}{5t} = \Delta V = \frac{30\sqrt{2}}{1/10}$$
$$= 420 \text{ fps error.}$$

This velocity error can be reduced by statistical methods of smoothing the curves to obtain useful data. For this reason, the principal use of the airborne cinetheodolite would be to determine aerodynamic characteristics such as pitch, yaw, roll, and path of trajectory.

Although air-launched missiles have been photographed from accompanying aircraft with tracking cameras, the design of a tracking sight that the pilot can use is a major problem. Tests made to date have involved an A3D airplane, which is roomy enough to accommodate a full-time camera operator. Because of the limited availability of such aircraft, a practical airborne cinetheodolite would need to be interchangeable with several single-place fighter-type jets.

Airborne Bowen Camera: Another variation of flying camera station would be to have a bank of fixed cameras which would function essentially as a set of Bowen cameras. These could be mounted in a wing-tip pod, with the position and attitude being determined by another camera photographing surveyed ground markers (Fig. 6). For tests where the desired trajectory coverage is limited and where a bank of cameras could be used, this would be a simpler operation and yet have approximately the same accuracy as the airborne cinetheodolite.

Conclusion

A flying camera station for missile coverage will be justified only at ranges beyond the useful limits of ground-based instrumentation. As the trend is toward smaller and faster missiles at higher altitudes, the demand is increasing for this type of instrumentation.

For aircraft orientation the flying camera station is very economical compared with a ground camera system and its associated range personnel and equipment. As the position accuracy is approximately the same, and attitude data are much better, the flying camera station is finding many uses in aircraft flight tests and instrument checks where attitude or position data are required.

Discussion

S. M. Lipton (Session Chairman): Would it be feasible to use tracking equipment with optical instruments in aircraft in an area which frequently has obscuring cloud conditions?

Mr. Kinder: That is actually what we are trying to prove: that we can track from an aircraft. Over clouds if you use gyros or some other artificial horizon, you can get your attitude information but you wouldn't get any trajectory data inasmuch as you would not have any position. The only basis for using a camera photographing the ground is to get position as well as altitude. But over clouds I think you'd probably use some other type or an artificial horizon.

Mr. Lipton: What is the maximum focal length you have been able to use on your lenses?

Mr. Kinder: The tests thus far are with a 16-in. lens on the camera; it's fixed and we just track with a mirror. We obtain fairly good results with that. We used it because it was convenient and available.

Optical Tracking Instrumentation

By A. H. SCHENDEL

The basic requirements for optical tracking instruments used in missile test work are outlined and a survey is given of the instrumentation presently in use and under development. Field operating conditions and data reduction aspects and possibilities for future developments to meet the increasing demands for highly accurate information on in-flight characteristics are discussed.

Optical instruments have been used for determining the location of moving objects and for studying their behavior since Galileo, about 350 years ago, directed his telescope toward the sky.

In this age of aircraft, rockets and guided missiles, there is a continuous demand for improvement of methods and instrumentation to determine the trajectories of fast-moving objects, to ascertain their position in space, their velocity and acceleration, and to obtain information on attitude, roll and on external and internal events occurring during the flight. A variety of optical and electronic systems have been developed to meet these demands.

In the field of optical instrumentation it was sufficient, in former years, to make visual observations with telescopes. Increased speeds of airborne objects necessitated the development of photographic techniques to "freeze" the motion of the object in space so that a detailed analysis of the events can be made.

Two distinct optical-photographic methods are in use:

(1) The photographic camera remains in a fixed position (orientation). This method employs cameras which possess a wide angular field in order to cover a large portion of the trajectory, the object being recorded either on a photographic plate or on a strip of film. This type of instrumentation and its application on the missile range are discussed by J. E. Durrenberger.[1]

(2) The photographic camera continuously tracks the object. This method is described here. First, the essential features of an optical-photographic tracking instrument are considered.

Presented on May 2, 1957, at the Society's Convention at Washington, D.C., by A. H. Schendel, Range Instrumentation Development Div., Integrated Range Mission, White Sands Proving Ground, N.M.
(This paper was received on November 8, 1957.)

Basic Requirements

To enable an optical tracking instrument to gather data on objects traveling at high velocities there must be:

(1) A long-focal-length telescopic system of high resolution to produce an image of the distant object of a quality and size adequate for obtaining the information wanted.

(2) A motion-picture camera to take photographs of the object at the required sampling rate, plus electronic equipment for synchronizing the camera and/or for recording time signals on the film to furnish a record of the events vs. time, and to enable correlation of the data with respect to other range instrumentation.

(3) A mount to carry the telescope and the camera, sighting telescopes and manual or power drives for smooth, vibration-free pointing of the camera at the target. In case the object is not readily visible, means have to be provided for acquiring the target, using information obtained from other instrumentation such as radar.

An instrument built to this specification will give a pictorial record of the external events vs. time from which information on attitude, roll, and other flight characteristics can be secured. To obtain position data, the instrument mount must be equipped with precision graduated circles and optical systems for photographic recording of the circles so that the azimuth and elevation angles under which the object was seen from the instrument site can be read from the film.

The determination of the coordinates (x, y, z) of a point in space by means of optical tracking instruments is based on a triangulation method requiring azimuth and elevation angle information from at least two instruments placed a suitable distance apart (base line). Obviously, a number of stations must be set up on the range to cover the trajectory of a missile. Because of the altitude and length of trajectories of modern missiles, an optical range instrumentation system is a fairly extended network of field stations requiring electrical power, wire lines or radio links, a time signal generator, control center, and competent personnel to accomplish the operation.

Tracking Instruments, Operating or Under Development

Cinetheodolites: An instrument widely used on missile ranges for trajectory determination is the Askania cinetheodolite (Fig. 1), developed by Askania Werke, Berlin, Germany. As the name implies, this instrument combines the features of a theodolite as used in geodetic work with those of a motion-picture camera. The camera provides for frame rates up to 5/sec. The individual frames are triggered by pulses transmitted from range timing. Interchangeable lenses of a focal length from 60 to 300 cm with relative apertures from $f/4.5$ to $f/15$ are employed. Tracking of the instrument in azimuth and elevation is usually accomplished by two operators using handwheels. One-man operation or remote control can also be provided. On each frame (Fig. 2), simultaneously with the image of the test object, a record is obtained of the azimuth and elevation

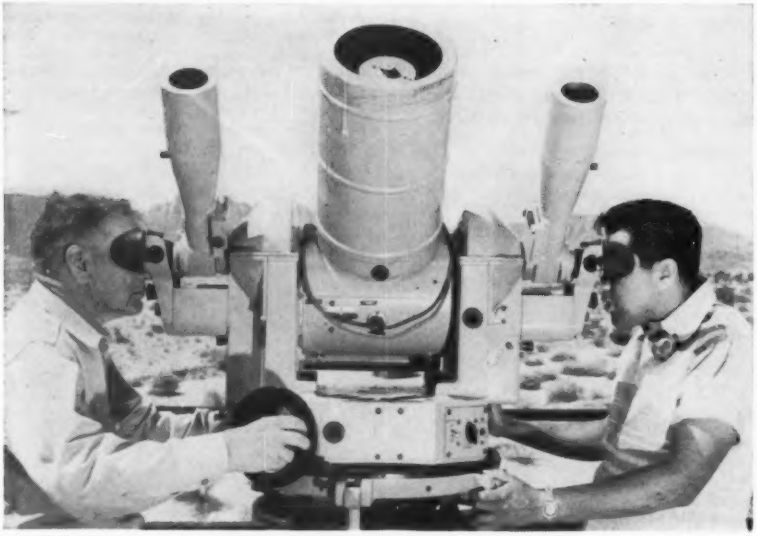


Fig. 1. Askania cinetheodolite developed in Germany.

circles, of a time code, and of a frame counter to correlate the data from several stations. Since the recorded azimuth and elevation angles refer to the direction of the optical axis of the camera lens, the displacement of the object on the film from the optical axis is the tracking error. By addition of the tracking errors to the recorded azimuth and elevation angles, the line of sight from the instrument to the moving object is obtained with a high degree of accuracy.

Improvements incorporated in these instruments during recent years or which are now under development include:

- Higher mechanical precision by refined manufacturing techniques;
- An open aperture plate with electrically illuminated fiducial marks;
- Automatic exposure control to improve the quality of the recording of the distant object;
- Intensity control for the flashlamps to insure optimum recording of the azimuth and elevation angles;
- Installation of coded circles to enable automatic reading of the photographically recorded azimuth and elevation angles;
- Means for target acquisition through use of chain radar data;
- Camera mechanisms for frame rates up to 10/sec;
- Aided tracking devices and seats for the operators to improve the tracking;
- Provision of dome-type shelters to protect the instrument from environmental effects (heat, rain, dust).

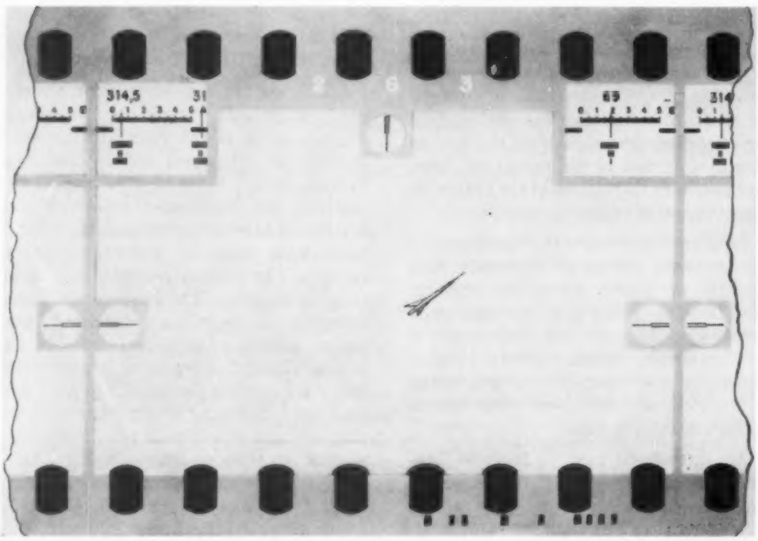


Fig. 2. Frame of Askania cinetheodolite film showing image of test object and record of coded azimuth and elevation circles, frame number and time code.

On some test ranges Askania cinetheodolites constitute the major or the only optical instrumentation system for trajectory measuring purposes. In their extensive use over the years, these instruments have rendered valuable service because of their inherent precision, reliability, ruggedness, and simplicity in construction and operation. These are factors of great importance for a missile test range where stations are located in remote areas and trained personnel are difficult to obtain.

Usually rates up to 5 or 10 frames/sec are considered adequate for covering long missile trajectories. For certain applications, higher sampling rates are desirable. This has led to the development of so-called high-speed cinetheodolites where conventional 35mm motion-picture cameras are used to achieve frame rates from 10 to 40 frames/sec. A detailed description of the modifications made on a standard Askania cinetheodolite to accommodate such a camera (Fig. 3) and of the electronic equipment for synchronization of the cameras by pulses supplied from a central time generator has been given by Lipton and Saffer.[2]

Another high-speed cinetheodolite called the E.O.T.S. (Electronic Optical Tracking System) has been developed by Contraves A.G., Zurich, Switzerland.[3] The characteristic features of this instrument (Fig. 4) include:

- A lens system of 150 cm focal length, aperture $f/8$;
- A 35mm motion-picture camera for synchronous operation at rates of 10 and 30 frames/sec;
- Readings of azimuth and elevation angles at two points on the circle to overcome eccentricity errors;
- Means for target acquisition and remote control, and
- Aided tracking of the displacement-velocity-acceleration type by two operators sitting on a rotating carriage.

Tracking telescopes: The term tracking telescopes is normally used for an optical instrument of substantially larger dimensions than cinetheodolites. For the majority of these telescopes, gun mounts which had become obsolete for their original purpose have been utilized. These mounts proved to have sufficient stability for carrying a large-aperture long-focal-length telescopic system and the motion-picture camera. Complete reconditioning or replacement of the bearings was necessary to insure the smoothness of operation required for tracking and photographic recording of distant objects.

Tracking telescopes of this type designated as "IGORs," (Fig. 5), "Gooney Birds," etc., have been described in previous papers.[4,5] These instruments, mostly equipped with telescopic systems

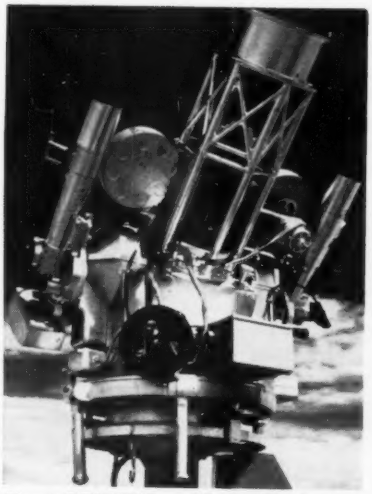


Fig. 3. BRL-NGF modified Askania cinetheodolite.

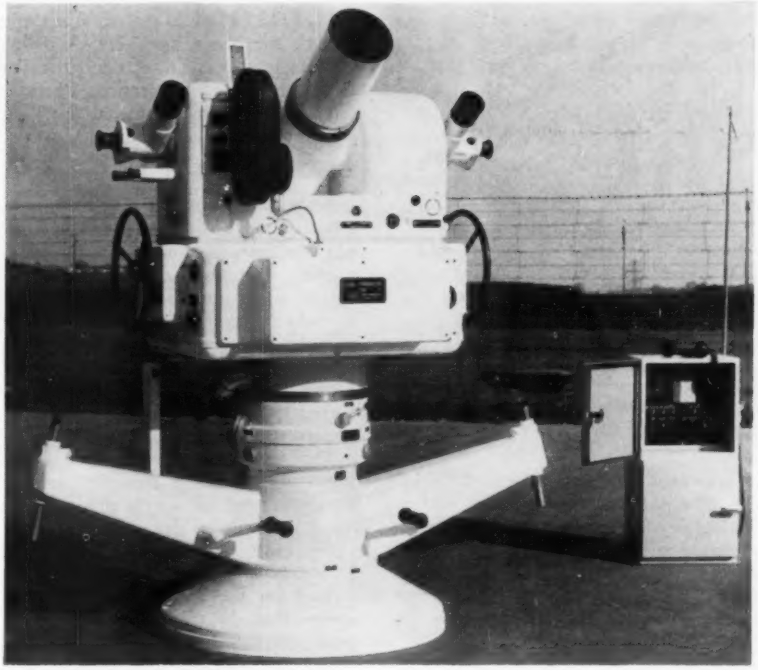


Fig. 4. Contraves E.O.T.S. theodolite.

of a focal length of about 100 in. and with a primary mirror of up to 18 in. in diameter, are mainly employed for supplying event data of the missile flight. The motion-picture cameras used are capable of rates up to 60 and 100 frames/sec and provision is made for the recording of time signals at the edge of the film. The latest version of an IGOR type telescope is presently being built by J. W. Fecker Inc., Pittsburgh, Pa., and will be installed at Patrick Air Force Base, Fla. It features a catadioptric system of 18-in. aperture with a choice of focal lengths between 90 and 500 in., using a 70mm full-frame camera. Automatic exposure and focus controls are included.

The most advanced instrument of this category of tracking telescopes is ROTI (Recording Optical Tracking Instrument) under development by the Perkin-Elmer Corp., Norwalk, Conn., for the Integrated White Sands Proving Ground-Holloman Air Force Base Range, N.M. ROTI (Fig. 6) uses a 5-in. Navy gun mount with a rotating carriage which supports a twin telescope in an over-under arrangement. A 70mm camera is supplied for each telescope and electronic equipment provides synchronous operation of the cameras and tracking of the mount. The upper telescope is of the Newtonian type, with a parabolic reflecting mirror of 16-in. diameter and a basic focal length of 100 in., which can

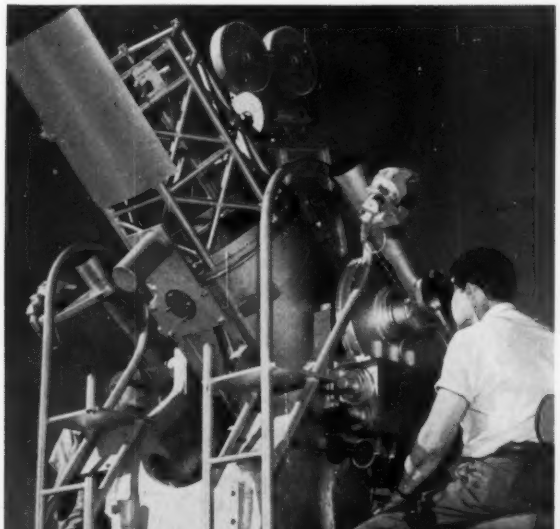


Fig. 5. IGOR tracking telescope.

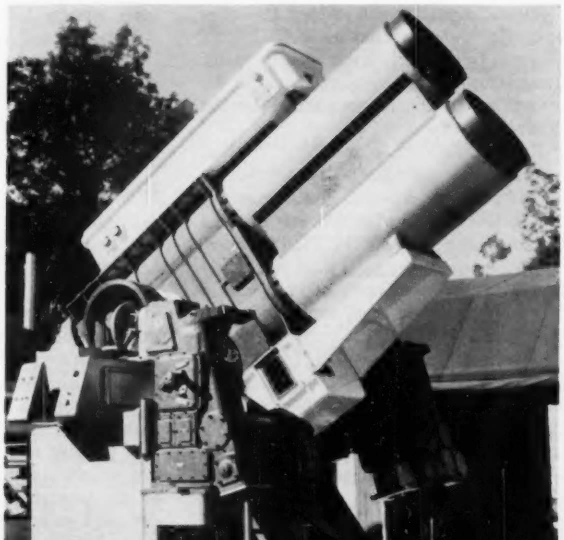


Fig. 6. ROTI Mark I tracking telescope.

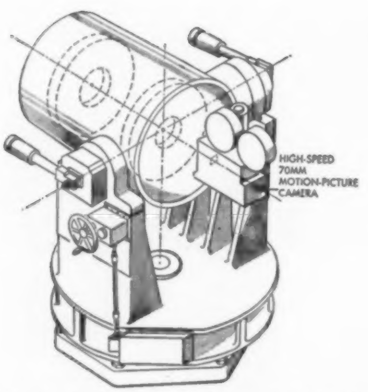


Fig. 7. Small Missile Telecamera developed by BRL.

be increased to 500 in. in steps of 100 in. by auxiliary power change optical systems mounted on a turret alongside the telescope tube. The lower telescope is of the Schmidt type with spherical primary reflecting mirror and aspheric corrector plate, variable in focal length from 50 to 100 in. in steps of 25 in.

The ROTI camera system consists of two 70mm cameras mounted on the two telescopes and a 35mm camera for recording of the azimuth and elevation angles. Coded circles installed on the instrument enable automatic reading of the films in data reduction, and records will be taken from two diametrically opposed points on the circles to compensate for eccentricity errors.

Tracking of the mount is accomplished by one or two operators using a so-called "stiff-stick" aided tracking method where the operator, by exercising slight pressure on a control knob, generates an electrical signal which brings the telescope in the direction desired. ROTI can also be remotely controlled by radar information and provision is made for overriding of the radar control by the operator.

ROTI Mark II, a modified version, has one telescope with a primary mirror of 24-in. diameter, basic focal length of 100 inches, and provision for stepping up the focal length to 500 in. Furthermore, this telescope is equipped with automatic exposure control[6] and an automatic focusing device utilizing range information supplied by radar.

These telescopes are used to obtain photographic records of missiles flying at high altitudes when other optical instruments, such as cinetheodolites capable only of accommodating telescopic systems of medium focal length, do not produce images of sufficient size for obtaining event information. The specification calls for a precision of the angle measurement of ± 30 sec of arc. It is expected that this value will be achieved or even be improved upon.

Two ROTIs will be installed at the Integrated Army-Navy Air Force Range, N.M. ROTI Mark II is already in use at Patrick Air Force Base, Fla. A mobile tracking telescope of similar design, called the Telescopic Photographic Recorder (TPR), has been completed for Eglin Air Force Base, Fla.

Recent Developments

Since use of obsolete gun mounts resulted only in an angular precision which did not permit the determination of missile trajectories to the required degree of accuracy, it became necessary to study the possibilities for mounts which with careful design, selection of materials, and application of advanced manufacturing techniques, would give data of higher quality than obtainable at the present time.[7]

The first large telescope for missile test work to use a specially designed mount instead of a gun mount is the Small Missile Telecamera (Fig. 7) being built by the Ballistic Research Laboratories, Aberdeen, Md. Tests performed on the prototype mount have shown that the trunnion carriage stays level within ± 2 sec of arc when rotated about the vertical axis. The striking feature of the optical system for the Small Missile Telecamera (SMT) is the large diameter (31 in.) of the primary mirror which provides for a relative aperture of $f/3.1$, at a focal length of 100 in. This optical system, a corrected Cassegrain type, is designed to give 20 μ resolution over a 1.5° field. A full-frame 70mm motion-picture camera will be used with the telescope and a 35mm camera for the recording of the coded azimuth and elevation circles. The SMT will have aided tracking equipment with associated power drives to allow tracking rates up to 10°/sec. The operator(s) will be seated on a platform driven independently from the instrument trunnion carriage. The first of these telescopes is scheduled for operational use on the integrated WSPG-HAFB range during 1958.

Field Operating Conditions

Providing the range with precision instruments incorporating the latest achievements in optical, mechanical and electronic engineering is, of course, of primary importance; however, this does not necessarily guarantee that the data collected will be of the quality desired. Only by careful study of the operating conditions and by development of adequate operational techniques is it possible to realize the full capabilities of the individual instruments and of an extended range instrumentation system. Factors to be considered include:

(1) Deployment of the stations so as to provide optimum geometric configurations relative to the part of the trajectory to be covered.

(2) Selection of the sites to avoid excessive tracking rates (e.g., beyond 15°/sec) and very low and very high elevation angles.

(3) Provision of an array of precisely surveyed target boards around the station to enable leveling and orientation of the instrument with respect to the range coordinate system.

(4) Application of calibration techniques to determine the magnitude of systematic errors inherent in the instrument. Special calibration devices are in use, and a final check of the individual instrument and of an entire system is made by means of star photographs.

(5) Setting up the instrument high enough above terrain to minimize atmospheric turbulence effects near the ground, and providing shelters to protect the instrument from sun radiation, wind, rain and dust.

Assuming that the above factors have carefully been observed and that synchronization of the cameras based on signals supplied from range timing has been accomplished, there still remains the major task of obtaining high-quality photographs of the distant object. Even if the telescopic system has been properly focused or is being automatically focused (e.g., using radar information), and even if the camera operates vibration-free, there is still a variety of factors which affect the forming of a high resolution geometric image on the film: Nonhomogeneities and turbulence in the atmosphere, through which the optical rays have to travel on their way from the distant object to the focal plane of the telescope, changes in contrast of the object against the background, and other phenomena affect the image quality. Detailed study of these conditions and of suitable light sources, such as flares, strobelights, and of special paints to be used on the missile to improve the visibility and recordability of distant objects, are in progress.[8-10] A great deal has been accomplished in the past by proper selection of filters, emulsions, exposure times and film processing. Under good atmospheric conditions excellent photographic coverage has been possible.

Data Reduction Aspects

Assessment of the raw data gathered in the field to secure missile position, attitude, and other information as a function of time, and presentation of the results in a final report constitute "data reduction."

For extracting the information from the films semiautomatic reading machines are generally used, the operator having only to perform certain settings manually while the result is automatically recorded on punched cards or tape.

Once the raw data have been compiled and corrections for atmospheric refraction, calibration and orientation constants have been applied to the observed azimuth and elevation angles,

computation of the space coordinates is usually done by combining data from three to five or more stations in a least squares adjustment solution. High-speed electronic digital computers such as the ERA 1103, IBM 650 and 704 are used for these computations.

Accuracy of position in space obtainable with optical tracking instruments depends primarily upon the following factors:

(1) Precision of reading the recorded azimuth and elevation angles from the film.

(2) Precision of reading the position of the test object on the film (tracking error).

(3) Precision in determining the calibration and orientation constants and other systematic errors, e.g., atmospheric refraction.

(4) Magnitude of random errors.

(5) Number of stations furnishing usable data and their geometric position relative to the point to be computed.

Optical instrumentation, especially when stars are used as a reference system, has given higher accuracy in space position than obtainable with other instrumentation. In fact, the data supplied from optical instrumentation are often employed as standards for evaluating other systems. Intensive error analysis studies of range instrumentation systems have resulted in establishing the areas and parameters which can best be secured with one or the other system. For example, x and y coordinates for a particular point in space can advantageously be computed from optical instrumentation but the height z of that point may better be determined from an electronic system. This has suggested the concept of combination systems in which a selection is made to insure the highest accuracy for those quantities which are most important to the test.

Development Trends

During recent years missiles traveling at higher altitudes and velocities have come to the test ranges and with them requirements for data of higher accuracy, often to be made available shortly after or even during the test (real-time data). This has increased the complexity of the workload on the range.

Higher accuracy of trajectory measurements could be obtained to a certain degree by improving existing instruments and operational techniques. In some cases this would require the application of more elaborate calibration and orientation methods and a greater number of stations. This in turn would necessitate more personnel in the field and in data reduction. The shortage of personnel makes this a serious problem.

To improve the situation, attempts have been made, so far unsuccessfully, to read automatically the position of the recorded object images (tracking errors) from the film. Notable has been the accomplishment of reading the recorded circle images. ORDRAT, an automatic dial reading machine developed by the Denver Research Institute under contract with Ballistic Research Laboratories, Aberdeen Proving Ground, and in coordination with the Range Instrumentation Development Division of the Integrated Range Mission, WSPG, will read azimuth and elevation angles from coded cinetheodolite films about 100 times faster and with about three times higher precision than possible manually.

It is being realized, however, that improvement of existing optical-photographic tracking instrumentation and acceleration of the reading of the films can only help in coping with the present workload. To meet future demands it will be necessary to employ novel techniques and particular emphasis must be placed on automatic collection and reduction of the data. This may lead to instrumentation systems providing for a continuous flow of the data from the various sites on the range to a central computing laboratory where the information desired could be computed instantaneously (real-time) or at a convenient time after the test.

Optical-photographic methods, because of the need for processing and subsequent reading of the film, do not lend themselves readily to automation. For certain applications, therefore, photographic recording may have to be discarded or supplemented by methods furnishing azimuth and elevation angle information in digitized form, suitable for recording on magnetic tape or electrical transmission to a central computer. Essentially, this requires the use of so-called shaft angle digitizers instead of precision graduated circles. Furthermore, devices are needed for instantaneous determination of the errors occurring with the tracking of the target. Correlation of the tracking errors with data from the shaft digitizers will then yield the azimuth and elevation angles from the individual sites required for real-time computation of trajectories.

Shaft angle digitizers of high angular precision are under development. For the determination of tracking errors two methods are being pursued:

With the first method the instrument is equipped with a refined aided tracking system to enable the operator to follow the object very closely. The remaining tracking errors, after a mathematical treatment in a "correction" computer which is an integral part of the instrument, are then available in digitized form. Tests performed with a prototype instrument, called RADOTT (Recording Angular Data Optical Tracking Theodolite), developed by the H. A. Wagner Co., Van Nuys, Calif., for the Naval Air Missile Test Station, Pt. Mugu, Calif., indicate that the angles derived in this manner, though the tracking error is dependent upon the operator's skill and alertness, compare in general with those obtained from cinetheodolites.

With the second method, instantaneous digitization of the tracking errors is accomplished by the installation in the focal plane of the telescope of light-sensitive elements, such as photo cells and television pickup tubes, designed to convert light energy into electrical pulses indicating the position of the target relative to the telescope axis. Besides supplying digitized tracking error information, the application of such optical-electronic devices may have the following advantages as compared to photographic methods:

No effect on the image quality by vibration of camera when operating at high sampling rates,
Easier synchronization and selection of sampling rates,
Longer operation time (no running out of film),
Possibly increased range coverage,
Automatic tracking possibility,
Control of image quality (focusing, contrast) during operation.

It can be seen that optical tracking instruments equipped with shaft angle and tracking error digitizers may become very useful for automation of the range. Of course, it will be necessary to weigh the capabilities of tracking instruments for solving certain problems with those of fixed cameras systems and those of electronic instrumentation systems to select the course of action which promises the best solution for meeting the stringent requirements of future missile test work.

References

1. J. E. Durrenberger, "Wide-field photogrammetric cameras in missile testing," presented orally on May 2, 1957, at the Society's Convention at Washington, D.C.
2. Sidney M. Lipton and Kennard R. Saffer, "The BRL-NGF cinetheodolite," *Jour. SMPTE, 61:* 33–44, July 1953.
3. G. Weber, "The electronic-optical tracking system," *Interavia*, No. 11, 1953.
4. Sidney M. Lipton, "Multipurpose optical tracking and recording instrument," *Jour. SMPTE, 62:* 450–459, June 1954.
5. Myron A. Bondelid, "The M-45 tracking camera mount," *Jour. SMPTE, 61:* 175–182, Aug. 1953.
6. George Economou, Vladimir Luban and Morton Mehr, "Automatic-exposure control for a high-resolution camera," *Jour. SMPTE, 67:* 249–251, Apr. 1958.
7. J. A. Clemente, "A design and operational philosophy for an ultra-precision tracking mount system for a missile test range," *Jour. SMPTE, 67:* 242–245, Apr. 1958.
8. S. Q. Duntley, A. R. Boileau and R. W. Preisendorfer, "Image transmission by the troposphere," *Jour. Opt. Soc. Am., 47:* 499–506, 1957.
9. E. P. Martz, Jr., "Visibility: Detection and recording of objects against a sky background," *Jour. SMPTE, 67:* 228–231, Apr. 1958.
10. H. C. Schepler, "Atmospheric optics," *Jour. SMPTE, 67:* 225–227, Apr. 1958.

A Design and Operational Philosophy for an Ultra-Precision Tracking Mount System for a Missile Test Range

By JOHN A. CLEMENTE

Test-range requirements for a ground-based instrument station which will combine optical, photographic, television, photoelectric and electronic event-observation and recording devices carried on a servo-driven tracking mount of theodolite accuracy are discussed. The system will obtain missile-performance data and produce records in forms suitable for use in automated data-processing systems. The tracking-mount configuration and design considerations are described in detail.

A GUIDED-MISSILE test range is essentially an outdoor or free-flight wind tunnel, instrumented to obtain quantitative data on the performance of developmental missiles and weapon system components.

The data required in guided-missile tests may be roughly divided into six types: (1) trajectory (space-position vs. time), (2) velocity, acceleration and drag coefficients, (3) attitude (pitch, yaw and roll with respect to the trajectory, and spin), (4) component functions, (5) relative-trajectory (booster separation, miss distance, multiple missiles or targets) and (6) internal functions.

To obtain these data, four classes of instrumentation are used:

1. Cameras or other recording instruments mounted within the missiles or aircraft. These instruments must be recovered to obtain the data.

2. Telemetering, which transmits data from internal instruments.

3. Electronic ground-instrumentation systems. These must be capable of obtaining line-of-sight angles, slant-range-to-target, or target radial velocity data, and are used to obtain position and sometimes velocity and acceleration information.

4. Optical ground instrumentation.

The related and interdependent roles played by optical and electronic ground-instrumentation may be considered by briefly examining five aspects of data acquisition as they affect electronic and optical systems.

1. Information Rate. This is the product of "bits-per-sample" and sampling rate. Electronic systems characteristically handle only one "bit" of information per sample, whereas an optical system that resolves 30 lines/mm is capable of presenting $1\frac{3}{4}$ million "bits" simultaneously on a 2-in. diameter image field. The electronic system may be capable of transmitting or recording a million or more samples per second while the optical images can be recorded on film at sampling (frame) rates limited to a few hundred per second. This can be illustrated by the television process wherein an optical system forms an image containing all the information in a scene at a given instant and an electronic system "scans" the image to pick off and transmit individual "bits" sequentially. The electronic sampling rate must be high enough to handle the total number of bits in the image in one inter-frame time interval if the optical and electronic systems are to have the same information rate. The large number of "bits-per-sample" characteristic of image-forming systems renders them capable of obtaining attitude or multiple target data.

2. Real-Time Data vs. Stored Data. Electronic systems generally produce data in the form of analogue electrical signals which can be recorded on magnetic tape, and processed, displayed and plotted all in a small fraction of a second, thereby making information available for immediate use in test-control and range-safety operations. Film recording, usually employed as the recording medium in optical systems, fails to provide real-time data in that the film must be processed and the data read off and translated into punch cards or magnetic tape before it is ready for further processing.

*3. "Augmented" vs. "Unaugmented" Modes of Observation.** Among electronic systems only skin-tracking radar is capable of tracking missiles without the aid of a transmitter or transponder in the missile. Beacon-tracking radars and all other electronic systems are "augmented," i.e., completely dependent on radiation from the target. Developmental missiles are frequently equipped with telemetering transmitters whose signals may be used by some ground-based electronic gear. Optical systems, working in the infrared, visible or ultraviolet portions of the spectrum, are capable of "unaugmented" operation and do not require any use of the radio spectrum. This capability permits coverage of small or multiple missiles incapable of carrying transmitters and also makes it possible to track targets during enforced "radio-silence" providing visibility conditions are not adverse due to clouds or nighttime.

4. Mount Vibration. Ground-based electronic angle- and distance-measuring equipment that operates without moving parts in the antenna systems obviously is not subjected to vibration. Vibration originating in azimuth and elevation power-drive elements and mechanical scanners in tracking radar systems does not deteriorate the data obtained. In optical systems, however, vibration originating in the mount power drives, in camera mechanisms, or even vibration set up by wind in resonant lens-support structures, can result in significant image deterioration and consequent impairment or loss of data.

5. Target Acquisition. The process of finding and bringing an instrument to bear on a hard-to-see, fast-moving target has been defined as "target acquisition." Some electronic systems are omnidirectional and will pick up any target within their range; and tracking radars are frequently provided with automatic-search devices. On the other hand, operators of long-focal-length narrow-field optical systems may encounter great difficulty in finding the target without assistance from instrument-positioning or target-designation systems.

Optical instruments in current use have been developed to meet specific data acquisition requirements brought about by the rapid expansion of the guided-missile art. As a result, none of the available instruments is capable of collecting all five types of external data, and it is customary to use cinetheodolites, high-speed tracking mounts, and tracking telescopes to obtain photographic coverage of a single test. Additional instrumentation for launching studies and real-time coverage is also required. It is apparent that we need a single-unit, integrated instrument system which

* The frequently misused terms, "active" and "passive," are not applicable here since they properly refer to the necessity for, or independence of, the emission of acoustic or electromagnetic energy by a detecting, seeking or tracking device. We are here concerned with requirements for emission, by the target, of energy in specified portions of the spectrum.

Presented on May 2, 1957, at the Society's Convention at Washington, D.C., by John A. Clemente, Test Dept., U.S. Naval Ordnance Test Station, China Lake, Calif.
(This paper was received on April 29, 1957.)

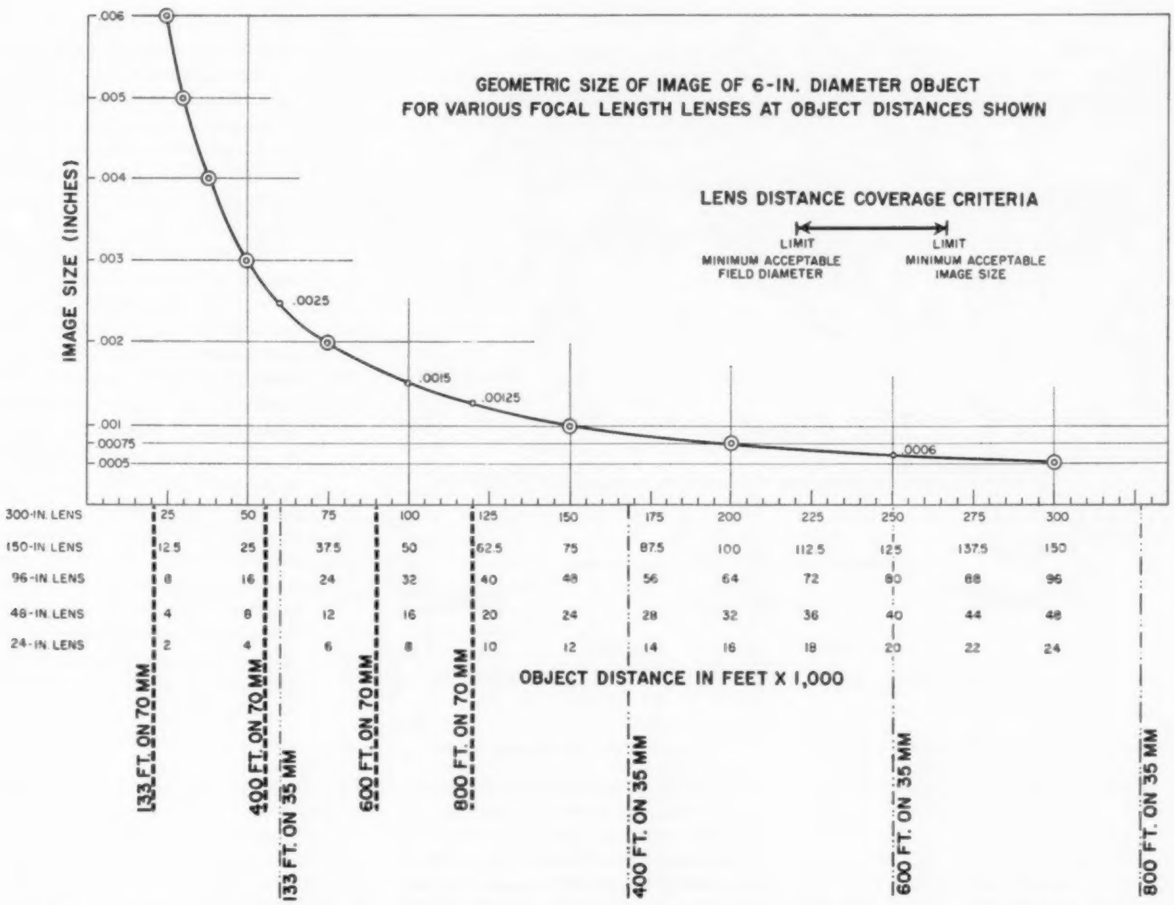


Fig. 1. Lens selection graph for long-range missile tracking instruments. Limits of 0.00075-in. image width and 600-ft diameter field have been chosen empirically for instrument design purposes at Naval Ordnance Test Station. Dotted lines show minimum distance for indicated coverage diameter in object space. – – – – – – – 70mm frame = 2-in. diameter field; —·—· —·— 35mm frame = 0.720-in. diameter field.

will combine the functions of cinetheodolites, high-speed mounts and tracking telescopes, to provide more accurate data, provide real-time data not now available from these instruments, and, through the employment of electronic accessory equipment, produce recorded data in a form suitable for direct entry into a fully automated data processing system.

The Tracking Instrument Mount or TIM System, now under development by the Navy's Bureau of Ordnance, is expected to fulfill these requirements.

Major Considerations in Design of Tracking Mount

The size of the tracking mount is determined by the event-observing gear to be carried, in this instance the lenses. It is intended that large long-focal-length optical systems will be used both for photography and in conjunction with automatic electronic image-scanning systems that will provide digital tracking-error data recorded on magnetic tape. Television cameras behind long-focal-length optical systems may be used in closed-loop systems for remote group-viewing of missiles in flight by test engineers, range safety officers, and others.

Since it is expected that the electronic scanning systems and television cameras will have approximately the same resolution and sensitivity as fast films, we shall consider only the photographic problems in choosing the lenses to be used.

As a result of field experience we may establish the following lens criteria: for reliable trajectory and relative-trajectory data the minimum geometric or computed width of an acceptable image shall be 0.00075 in. In order to assure an acceptable number of frames containing images of both the missile and its target at intercept, and to cover dispersion patterns of multiple missiles, the field of view at the target must be at least 600 ft in diameter.

Reflectors or catadioptric-type lenses of long focal lengths can be produced to cover image fields up to 2 in. in diameter with relative ease, whereas larger fields are difficult to obtain because of the larger obscuration ratios and higher-order corrections which they require. By coincidence, a 70mm cine camera with a 2-in.-square frame is the largest camera which can be produced for use with standard film and be capable of frame rates up to 100/sec. It is required that the TIM System be capable of obtaining data on a 6-in.-diameter missile at all slant ranges between 10,000 and 100,000 ft and in addition meet the above criteria. As indicated in Fig. 1, several lens-camera combinations will be needed. For example, four 70mm cameras (2-in.-diameter field) equipped with lenses of 27-, 48-, 83- and 146-in. focal lengths, covering ranges of 9,000 ft to 20,250; 14,400 to 36,000; 24,900 to 62,250; and 42,800 to 109,500 ft respectively, would provide 10% margins and 50% overlapping coverage.

For attitude and component-function data and special documentary coverage, where maximum obtainable image sizes

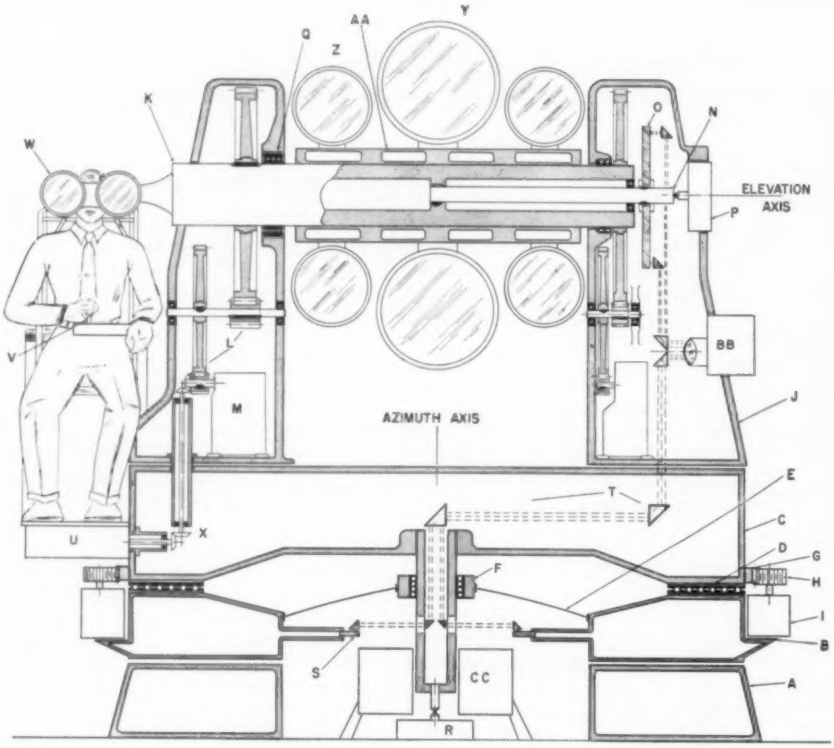


Fig. 2. Mechanical Schematic of TIM: A, base ring; B, upper base casting; C, azimuth rotating platform; D, azimuth thrust bearing; E, compliant diaphragm mounting for azimuth guide bearing; F, azimuth guide bearing; G, azimuth drive ring gear; H, azimuth drive pinion gear; I, azimuth drive motor and gearbox; J, elevation standard; K, elevation main shaft; L, elevation drive gearing; M, elevation drive motor and gearbox; N, elevation data shaft; O, elevation glass divided circle; P, elevation shaft-angle digitizer; Q, elevation bearings; R, azimuth shaft-angle digitizer; S, azimuth glass divided circle; T, circle reading optical train; U, operator's position; V, servo-drive control; W, operator's tracking telescope; X, operator's position drive gears; Y, 18-in. diameter telescope objective; AA, instrument supporting platform; BB, circle recording camera; CC, electrical slip-ring assembly.

are needed, and where the field of view may in some cases be as small as 60 ft in diameter, lenses with effective focal lengths up to 300 in. will be used. Relative apertures of T-10 have been found to be adequate for 1/1000-sec exposures with 4X filters on black-and-white film, and for 1/500-sec on color film. TIM lens systems will be designed for use with post-image magnification at two or more effective focal lengths, with the absolute aperture determined by the longest focal length. A typical lens system for TIM will be 12 to 18 in. in diameter, and 2½ to 6 ft long. Although not all stations will be required to cover the entire range of distances within the instrument capability, it is probable that some mounts will be equipped with as many as six lenses (with effective focal lengths of 24 to 300 in.), two 35 mm and two 70mm cameras, and two electronic image-scanners. From this we conclude that the mount must have provision for mounting up to three optical systems above and three below the elevation main shaft (Fig. 2).

Considering the maximum payload or instrument complement indicated above, and the necessary provision for "dumping" the telescopes for forward and reverse sights, the requirements are about a 3½-ft minimum clearance between the mount elevation standards, a 4-ft swing clearance below the elevation axis, and a load-carrying capacity on the elevation bearings (including the weight of the elevation main shaft and the instrument support structure) up to 4,000 lb. These dimensions and loads in the elevation assembly imply that the azimuth rotating platform will be approximately 8 ft in diameter, and that the entire structure rotating around the azimuth axis will weigh around 10,000 lb.

Data Accuracy Requirements

In order to meet data-accuracy requirements, design goals for the mount have been set at 2 to 3 sec of arc for azimuth and elevation axis-wobble, perpendicularity of the axes, structural deflections (caused by mechanical loading and thermal effects), accuracy in the divided circle and digitizer angle-measuring systems, and determination of mount mislevel and lens collimation.

It is felt that azimuth bearings or roller-paths of conventional configurations — balls or rollers running in steel races which are supported on, and subject to the constraints of, large castings or weldments many times more rigid than the races — cannot be expected to attain this accuracy consistently under range conditions. The azimuth bearing configuration proposed for TIM combines a thrust element, employing 2,000 to 3,000 small steel balls distributed in an annular space between upper (rotating) and lower (fixed) plane surfaces produced directly on the parent metal of the main castings or weldments, with a compliantly mounted guide bearing to provide only radial constraint without redundancy in determination of the axis of rotation.

The elevation bearings, being spread approximately 5 ft, present a much simpler problem in attaining the desired accuracy, provided the elevation shaft is stiff enough. It is proposed that the TIM elevation main shaft will be a tube made of the same material as the major mount elements, be approximately 10 in. in diameter, and pass unbroken through both sets of standard bearings with both radial and longitudinal constraint on one end and only radial constraint on the other end.

To minimize vibrations and strains in the mount structure, which will be required to track at rates up to 60°/sec with momentary accelerations as high as three radians per second per second, the azimuth drive will be applied to the rotating member by four fixed motors operating in parallel and disposed at 90° intervals around the rotating platform — thus distributing and reducing the amplitude of stresses, balancing out radial forces on the guide bearing, and reducing the size and mass of rotating elements. If possible, a timing belt final drive will be used so that pure tangential driving forces will be applied to the azimuth rotating platform, metal-to-metal gear contact and localized high tooth pressures will be eliminated, lubrication and oil- or grease-tight housings and seals will be unnecessary, and the effects of manufacturing tolerances, wear, or departure of the large ring gear from true circularity will be minimized. (In a single-pinion-gear drive system, defects, wear, or distortion, in

either the pinion gear of the 8-ft-diameter ring gear, resulting in as little as 0.0002-in. backlash, could cause significant vibration.)

Stresses originating in the elevation drive system will be distributed by using two parallel drives in the standards. This reduces the size of rotating elements and minimizes torsional stresses in the elevation shaft.

Materials used in the mount's main castings or weldments should be carefully selected for stability and vibration-damping properties, and dead-annealed before final machining to assure that initial accuracy built into the mount can be maintained over a long period of field operation.

There should be the tightest possible angular coupling between the optical system lines-of-sight and the elevation-glass divided circle and shaft-angle digitizer. A coaxial data shaft, located inside the tubular elevation axis main shaft and free from torsional and bending loads, will connect the elevation divided circle, shaft angle digitizer and the elevation synchro transmitter system directly to the main shaft in the center of the payload area.

Three independent systems for measuring and recording azimuth and elevation angles will be provided in the TIM mount. First, the readings of coded, graduated glass circles on the azimuth and elevation axes will be recorded on film with strobe lamps. The film records will be assessed in semiautomatic reading machines capable of reading the angles to a least count of 0.001 degree. Tracking-error corrections to these records will be read from the long-focal-length target-camera films. Second, gear-driven synchros and resolvers will supply continuous electrical analog signals (uncorrected for tracking errors) for real-time applications. These signals will be used to operate plotting boards, as angular position references in master-slave operation and in positioning the mount in response to information received from target-acquisition systems. Third, shaft angle digitizers will provide precision digital azimuth and elevation-angle records on magnetic tape. These records will be combined with tracking error corrections on magnetic tape, obtained from the electronic image-scanning devices mentioned earlier, for direct entry into a fully automated data-reduction system.

The azimuth and elevation servo-drive systems will respond to signals originating in the operator's control element, to position or rate data received from preset programming devices or target-acquisition systems or to error voltage signals generated in the electronic image-scanning systems, thus providing local, slave, or automatic-tracking modes, respectively.

The operator will always have override control when in slave or automatic-tracking modes.

Because of high peak personnel loads implicit in test-range operation, the TIM must be manned by a single operator. Maximum utilization of the operator's abilities will be facilitated by the application of human engineering techniques to the design of the operator's position and controls. The electronic servo-control system will be designed for maximum flexibility in the introduction of various transfer functions to obtain optimum smoothness and accuracy of tracking under all range conditions.

It has been found that random momentary obscurations in the human eye cause an operator to lose sight of distant targets when the image approaches the vanishing point. The operator's telescope on TIM will be a binocular-type to assist the operator in tracking to maximum ranges.

TIM systems will be installed on specially constructed towers and protected by power-driven astrodome-type enclosures, especially at down-range sites, to provide extended range coverage. The TIM System, because of the integrated design employing both optical and electronic means for obtaining data, will provide great flexibility in coverage, real-time data and pictorial coverage, and stored-data in forms compatible with the highly automated data-processing systems now being developed.

The benefits to be derived from this system, which include more accurate test data than are presently attainable, more rapid delivery of test results to weapons development agencies, significant improvements in instrument dependability, and economies effected in range operations and data processing, are expected to make the TIM a basic ground instrumentation system for guided-missile test ranges.

Discussion

A. M. Erickson (*Naval Ordnance Laboratory, White Oak, Md.*): Is it correct that the mount is capable of 50 or 60 degrees per second tracking rate?

Mr. Clemente: That is one of the requirements.

Lincoln L. Endelman (*Convair Astronautics, Cocoa Beach, Fla.*): If this isn't classified, approximately how soon do you expect to have some of these in operation?

Mr. Clemente (*by mail*): The American Machine and Foundry Co. is currently working on the design of TIM under a Bureau of Ordnance contract for complete drawings and specifications for prototype production. The design is scheduled for completion in March 1959, with actual construction of prototypes to follow.

At the Convention Mr. Clemente advised: It occurs to me that much of the material that was discussed previously this afternoon had to do with large missiles, or other objects at distances up to several hundred miles. I think it should be made clear that the mount discussed in this paper is intended primarily to handle up to distances of something less than 100 miles, and that many of the missiles may be only the 6-in. diameter missile that we took as a standard in determining lenses.

Photographic Instrumentation at the Air Proving Ground Center

By H. C. SCHEPLER

Precise spatial position of airborne test objects such as rockets, bombs and missiles is recorded photographically on the Air Force Armament Center test ranges. The instrumentation employed, the use of triangulation in determining spatial position and the accuracies obtained are discussed.

It is the responsibility of the Air Force Armament Center to determine engineering performance characteristics of various types of armament. Answers are required for such questions as: Why do certain mechanical linkages exhibit malfunction during armament release from aircraft? What is the precise acceleration curve and the trajectory of a rocket from firing to burnout? What are the causes for failure in bomb release mechanisms? The answers to these and similar questions are found only through photography. (Missiles, bombs, rockets and other projectiles will hereinafter be referred to as airborne targets, or targets.)

Perhaps the most important and also the most difficult problem in airborne armament testing is to determine the precise position in space of an airborne target. Spatial position is determined most precisely by triangulation methods from photographs taken simultaneously and at known times by two or more cameras from established geographic positions. This provides three basic requirements for determining accurately the spatial position of airborne targets: (1) several cameras located in a coordinate system, (2) means for establishing angular position from camera to target, and (3) means for recording the time that each photograph was taken.

Use of Cinetheodolites

Instrumentation used to track airborne targets had its beginnings about 1940 with the development of Askania cinetheodolites in Germany. These were first used to test V-I and V-II missiles at Peenemunde. Since then cinetheodolites have been used in many countries for testing guided missiles and other airborne targets. The Air Force Armament Center uses Askania cinetheodolites procured from Germany and Contraves cinetheodolites procured from Switzerland for such test work.

Spatial position of a target at a given instant of time is obtained with cinetheodolites by triangulation from at least two photographs taken simultaneously by cameras with a rather large base line distance between them. This base line may be one mile or several miles long, depending upon the particular problem at hand. A minimum of three cinetheodolites is used to photograph the target simultaneously since measurements from three films in most cases provide highest efficiency in terms of accuracy vs. data reduction time consumed.

Tracking is usually accomplished by having one operator control the azimuth position and another the elevation position of the camera by visual observation of the target through two appropriately aligned telescopes. Both operators keep the target in the field of view of their sighting telescopes and hence in the field of view of the camera by rotating the instrument about its vertical and horizontal axes while tracking the target. Azimuth and elevation scale readings and film frame number are photographed by flash illumination onto each film frame taken of the moving target. When the cinetheodolite is prepared for operation the azimuth and elevation scales are oriented with respect to a fixed coordinate system. Fiducial marks are recorded on each film frame as a fixed reference to determine the optical orientation axis of the cinetheodolite. Photographic data are recorded double-frame size on 35mm film taken at sequential rates up to 30 frames per second.

In data analysis the distances from the reference fiducial marks to the target image are measured on the processed film. Knowing the focal length of the lens the image off-axis position (tracking error) is converted to an angular value and integrated with the scale recordings of the cinetheodolite to give the true angular position of the target from that particular camera location at a known instant of time. Target spatial position is then determined in data analysis from this camera film frame and film frames taken at the same time by other cinetheodolites.

Time pulses sent out to all instruments from a central timing system synchronize all flashlamps and trigger the camera shutters and film advance mechanisms.

Shutter Speeds

It is important that the shutter speed be fast enough to "stop" image motion during maximum acceleration and tracking rates. The Contraves cinetheodolite shutter speed is $\frac{1}{120}$ sec at 30 frames/sec. The maximum acceleration of the instrument is 60°/sec/sec and the maximum velocity is 30°/sec. The Contraves is provided with a rate servo aided tracking system and the maximum tracking error encountered for maximum velocity is about 1 mil.

Cinetheodolites usually require long-focal-length lenses and fast film. The Contraves has a photographic lens system of 1500mm effective focal length and commonly employs Shellburst Panchromatic film with an ASA speed of 200. The overall accuracy of the Contraves approaches one part in 18,000. This is considerably better than accuracies obtained to date with similar systems in operation on the Air Force Armament Center ranges.

A high-speed photographic application similar to the one just described is employed in the testing of rockets. Spatial positions of rockets through and slightly after burnout are determined on a rocket test range. Airborne rockets are ground tested by accelerating them up an inclined track to normal aircraft velocity. A sled carrying the rocket is driven up the track by high thrust rocket motors. The track is 500 ft long and has a 5° incline. The rocket is fired as the sled reaches the end of the track. For a typical firing, the velocity of the sled at launch is 1000 ft/sec and the rocket velocity at burnout is 3200 ft/sec.

Camera Installations

Fixed cameras are used for the rocket tests and are located so as to photograph the rocket from the rear and from the side as it leaves the sled. The camera found best suited to these applications is the CZR-1 (Bowen) acceleration camera (Fig. 1) manufactured by Mitchell Camera Corp. The CZR-1 is not a tracking camera and it is designed for the specialized purpose of obtaining film recordings of the trajectories of rockets, missiles and other projectiles. The data from the film record are used to calculate the velocity, acceleration, fin opening, spin, dispersion, burn-out time and other ballistic characteristics of the test item during launching and the early portion of the flight.

Seven of these cameras, spaced at 450 ft intervals, are located along each side of the rocket trajectory or flight line at 1000 ft from the flight line. Four more CZR-1 cameras are located along each side of the flight line at greater spacings

Presented on May 2, 1957, at the Society's Convention at Washington, D.C., by H. C. Schepler, PGEP, Air Proving Ground Center, Eglin Air Force Base, Fla.
(This paper was received on April 18, 1957.)

and at greater distances from the flight line than those previously mentioned.

The theoretical trajectory of the rocket is computed from static test data which provide adequate information for positioning and orienting the CZR-1 cameras so that the rocket trajectory will fall successively in their fields of view. When setting up a camera, it can be rotated about azimuth, elevation and roll axes in order that the rocket images will fall in the long direction of the film frame after the rocket is fired.

In this application of the CZR-1 camera the frame rate is 30 frames/sec on a film frame size 0.9 in. high by 5 in. wide at a frame exposure time of 1/10,000 sec. Time in minutes and seconds down to 0.0001 sec is photographed onto each film frame from a binary coded time display appearing as a dot raster on a cathode-ray tube. This complete time readout is presented every 100 μsec and is gated to the frame speed.

The CZR-1 camera takes a long and narrow film frame size at frame rates up to 180 frames/sec. A standard 100 ft roll of film $5\frac{1}{2}$ in. wide is driven past a rectangular aperture that establishes the film frame size. The shutter is a series of 6 slots in a rotating drum that passes between the moving film and the rectangular field aperture. The frame rate can be set at 30, 60, 90 or 180 frames/sec by the proper selection of the number and sequence of shutter slots left open. Any of the shutter slots may be closed by means of shutter slides. Whenever the frame rate is changed, an appropriately dimensioned aperture slide or frame must be inserted in the rectangular camera aperture to change the vertical dimension of the individual photograph. The aperture insert with the largest opening is used with the lowest frame-per-second rate.

The shutter drum is driven directly by its own synchronous drive motor. Shutter rotational speed and film transport speed are maintained at a constant rate with film transport being accomplished by a separate motor drive through a series of reduction gears and specially designed clutches. These clutches perform two functions: the maintenance of a constant predetermined tension on the film through the take-up spool and prevention of film transport until the film transport drive motor has attained its full operating speed. Thus during camera operation the film moves in the direction across the narrow part of the film frame. The film is actually moving during exposure but the high shutter speed used does not materially reduce resolution in the direction of film movement. The direction of target travel is imaged onto the film at right angles to the direction of film movement in the camera. Thus the resolution of the target image in its direction of travel is

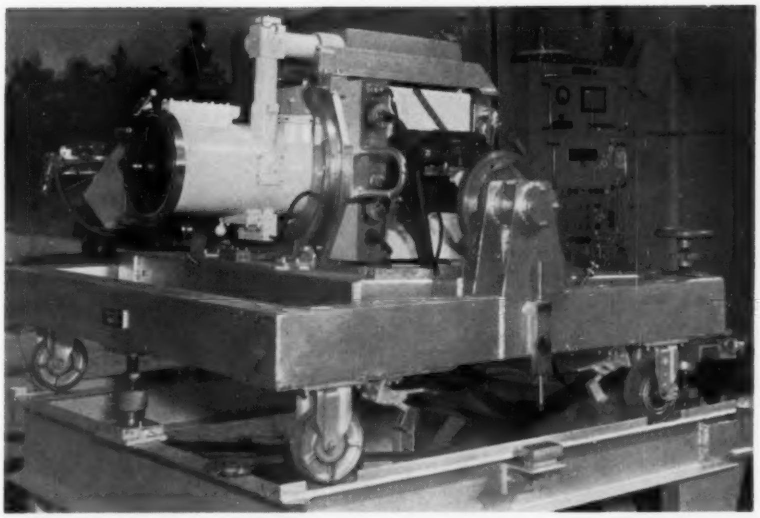


Fig. 1. CZR-1 (Bowen) acceleration camera used for obtaining film recordings of trajectories.

not impaired by film movement during exposure.

The CZR-1 camera is adaptable to and well suited for multiple-camera test operations. Arbitrary selection of any one camera as the "master" is possible for purposes of "phasing in" the shutter drums of the other cameras usually designated as slave cameras. Each camera has a self-contained strobe unit. An integral pulse or "pip" generator is connected in a manner which feeds the synchronizing or phasing pip signal from the master camera to the strobe units of the slave cameras. Adjustment of the shutter drum phasing control on each slave camera as required, insures shutter drum synchronization for all cameras in the system. Additional camera features provide a timing mark on the edge of the film which is used in precision determination of interframe time intervals, film footage and temperature indicators and a reference mark projector which places three reference marks in the form of crosses across the film width. These marks provide a means to determine film distortion caused by processing and also serve as reference points for all measurements. The CZR-1 optical system is shown in Fig. 2.

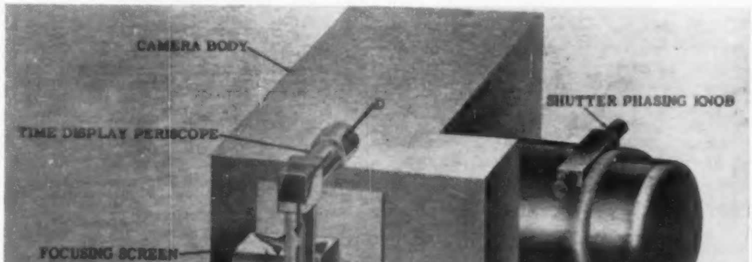


Fig. 2. CZR-1 optical system. A, B, C and D define the reference mark and timing systems.

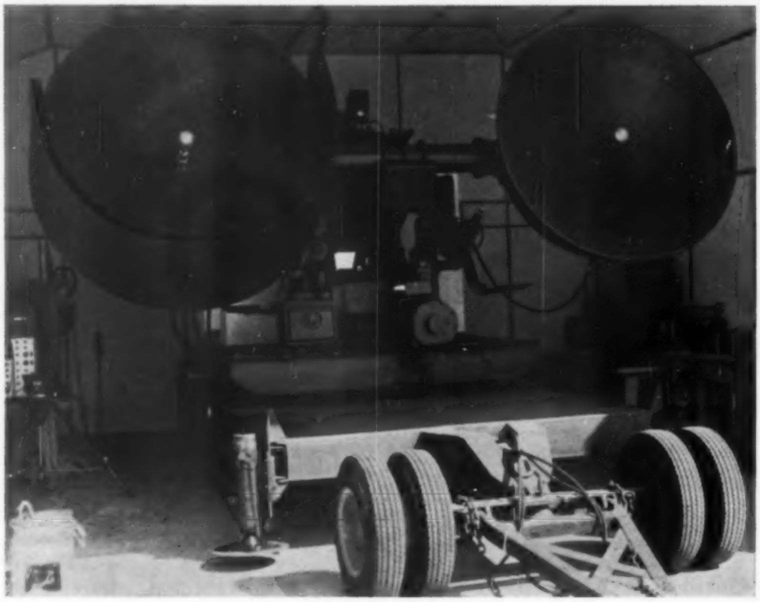


Fig. 3. Doppler Velocimeter.

Located beside the end of the track are three high-speed Mitchell cameras with lens focal lengths of 1 in., 6 in. and 15 in. which photograph the rocket from the rear at 128 frames/sec. Time in code is put onto these Mitchell photographs with neon lamps. Another high-speed Mitchell camera, located directly in front of the track so that the rocket and sled pass over the camera, records how far off side the rocket goes in its trajectory. Rocket spatial position and trajectory are determined at successive instants of time from these Mitchell and CZR-1 cameras. Rocket firing time is recorded on a 16mm ground event camera which has continuous moving film at 20 in./sec. Real time is also recorded on this camera so that rocket firing time can be established on the Mitchell and CZR-1 camera films. Other 16mm and 35mm Fastax cameras are used at 5000 frames/sec to observe the sled while going up the track.

Doppler Velocimeter

The Mitchell and CZR-1 cameras provide photographic data on the accelerations and velocities of the rocket with high accuracy. However considerable film must be read and measured to make these determinations. A less accurate auxiliary system is therefore used to make a much faster determination of these characteristics. The instrument used in this auxiliary system is the Doppler Velocimeter (Fig. 3) which is located directly behind the track. From this instrument a radio wave of known frequency is beamed at the rocket. The return reflected wave combined with the wave sent out is recorded as a Doppler wave which, when associated with time, provides the velocity of the rocket. The Doppler signal and a time code are recorded on magnetic tape. The tape is run through a dual beam oscilloscope which is photographed by a Fastax camera with its rotating prism removed. The result is the Doppler wave and the timing code recorded side by side on the film. The velocity of the rocket at any instant of time is determined by counting the number of Doppler waves per unit time as determined from the time code.

Discussion

A. M. Erickson (*U.S. Naval Ordnance Laboratory, White Oak, Md.*): How do you calibrate one of these cinetheodolite machines to get an answer that corresponds exactly with the actual conditions in the field?

Mr. Schepler: We use both laboratory and field calibration methods for our cinetheodolites. In the laboratory we make complete checks of the optical system. We check distortion of the lens, obtain the distortion curve, determine that the optical axis of the lens is symmetrical with the symmetry of the distortion curve and make measurements of the lens aberrations. In the field we run evaluation tests with target boards surveyed in to first-order survey and we make measurements on the film frame to determine the aberrations for field conditions.

Another problem we are pioneering in at the Armament Center is the accurate calibration of the instrument scales. These are marked on a glass disk to $\frac{1}{2}$ and can be read to about 6 sec of arc by means of a scale divider arrangement. We have used various methods for calibrating the scales. We are about to receive delivery of an angle-measuring interferometer with which we will be able to measure an angle to an accuracy of hundredths of a second. This will give us something to spare in checking the angular calibration of these scales.

Lincoln L. Endelman (*Convair Astronautics, Cocoa Beach, Fla.*): What is the focal length of the lenses used in the Askania; how does the operation of the Askania compare with that of the other type of theodolite; and approximately how many stations does it take to give you a good three-station solution?

Mr. Schepler: The Askania lenses originally obtained from Germany after the War were 24 in. or 60 cm in focal length. There are also a few 30-cm focal-length lenses in this country, but our demands for taking photographs at greater ranges are such that the 30-cm lens, to my knowledge, has never been used in this country. Many of our ranges have built, or have had built, longer-focal-length lenses for the Askania. Holloman Air Development Center has built lenses with a focal length of 84 in. For some applications, lenses up to 120-in. focal length have been used. However, these lenses are quite unwieldy because it is difficult to balance the instrument so that you get smooth tracking, particularly in elevation. The Perkin-Elmer Corp. has built some 48-in. and 60-in. focal-length lenses for Patrick AFB, and some long-focal-length Ransom lenses are used at Holloman and at other ranges.

In contrast, the Contraves cinetheodolite has a five-foot focal length lens that is not interchangeable. We are presently interested in having this optical system redesigned to a longer focal length.

We have found that the accuracy of the Contraves cinetheodolite is better than that of the Askania. The Askania is generally considered to give an accuracy of ± 20 sec of arc. There is not good agreement on this figure among various ranges. Experience with the Contraves indicates an angular accuracy of about ± 10 sec of arc.

We seem to get the most for our money in terms of data reduction by using a three-station solution. From the point of view of data reduction time required, it is usually impractical to reduce data from more than three cameras. You do gain a very small amount by using more than three, and successively less improvement as you reduce data from more cameras. So data from three cameras are, I believe, rather generally used at the various ranges. There have been special tests run at NOTS using eleven cameras for an eleven-station solution for particularly close calibration work.

Automatic-Exposure Control for a High-Resolution Camera

By GEORGE ECONOMOU, VLADIMIR LUBAN and MORTON MEHR

Photography of distant objects requires accurate exposure to achieve maximum contrast with high-contrast emulsions. The autoexposure unit described in this paper has been designed for the ROTI Mark II tracking instrument to provide the necessary control. A pair of graduated neutral density disks is used to vary the light level at the film plane. By maintaining full aperture, maximum resolution is achieved for all light conditions.

THE ROTI MARK II TELESCOPE SYSTEM was designed to photograph missiles at extreme slant ranges. Maximum optical resolution was desired and therefore a telescope was designed with a 24-in. aperture and focal lengths of 100 to 500 in. The telescope has a highly corrected optical system with a laboratory resolution of $\frac{1}{3}$ sec of arc (theoretical limits of resolution are $\frac{1}{5}$ sec). A 25-ft tower supports the ROTI telescope on its roof to minimize the effects of ground level atmospheric disturbances (Fig. 1). Radar-controlled focusing adjusts for target range variations.

At long slant ranges, atmospheric attenuation results in low contrast between the object and background. For recording the maximum of information, it is necessary to use high-contrast emulsions and high-contrast developing. Increases in image contrast are limited by corresponding decreases in exposure latitude; therefore an automatic exposure control system was included in the ROTI Mark II tracking instrument. The autoexposure unit maintains a constant average light level at the film plane of the 70mm Photosonics motion-picture camera as the target crosses backgrounds of varying brightness.

Exposure Controls

Three methods of controlling exposure were investigated. A method utilizing variable-density polarizers was considered. It was rejected because absorption through the polarizers would have greatly decreased the light transmission of the system.

A second method considered involved the use of a variable iris, but the diffraction effects of the stop would have deteriorated the resolving power of the system. Resolution limits are a direct function of the focal length and aperture, and it would have been possible to reduce the iris by only one stop before the system resolution dropped below tolerable limits.

The method selected was to decrease evenly the transmission of the system across the entire aperture with a variable, neutral-density filter. Opposed disks with linear density coatings were designed to provide an equivalent 5-stop variation while maintaining even illumination across the field.

The disks were made of optical glass coated with Inconel and the density was a linear function of angular rotation of the disks within $\pm\frac{1}{8}$ stop, or about $\pm 10\%$ transmission. For coating, a wheel with variable width slots was rotated between the disks and an evaporating filament. The Inconel particles flowed to the glass through the slots which were adjusted to yield a gradient density which would give the proper slope to the transmission curve.

General Operation

The ROTI Mark II autoexposure unit was designed to maintain a constant level of illumination at the film plane with $\pm\frac{1}{4}$ stop accuracy. Ambient light within 32:1 range could be accommodated by a single setting.

In order to minimize manual adjustments to compensate for changes of focal lengths and color filters, samples of entering light are monitored by a detector. Ultimately the detector and associated servo system adjust the position of the variable-density disks. The level of illumination is sampled by four pick-off mirrors at the edge of the cone of light which converges at the camera aperture. These mirrors divert a portion of the light to the measuring portion of the system. The sampled light is proportional to the light reaching the film plane. Figure 2 is a block diagram of the autoexposure unit.

The measuring unit operates on a null principle alternately comparing a reference light with the entering light. The reference lamp operates from a 28-v source. The chopper operating at 1800 rpm is a transparent plastic disk with four alternate clear and reflecting quadrants. The clear sectors transmit while the aluminized sectors alternately reflect the reference light to the 1276 photomultiplier. The light projected in the photomultiplier becomes a 60-cycles/sec modulated signal and the amplitude of the signal is determined by the difference in intensity between the two light beams (Fig. 3).

The reference light is separately monitored. A beam splitter reflects a portion of the reference light to a selenium photocell and indicating micrometer. A rheo-

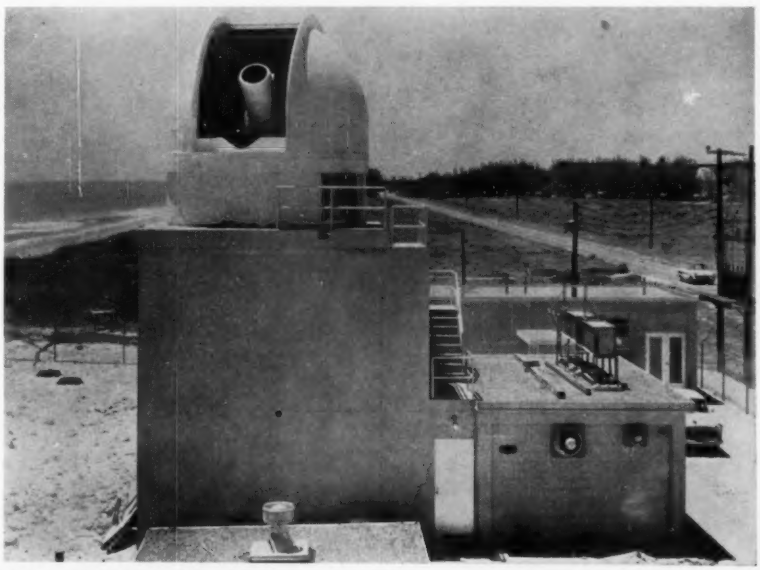


Fig. 1. ROTI Mark II installation.

Presented on October 9, 1957, at the Society's Convention at Philadelphia by George Economou (who read the paper), Vladimir Luban and Morton Mehr, Engineering and Optical Div., Perkin-Elmer Corp., Norwalk, Conn.
(This paper was received on September 20, 1957.)

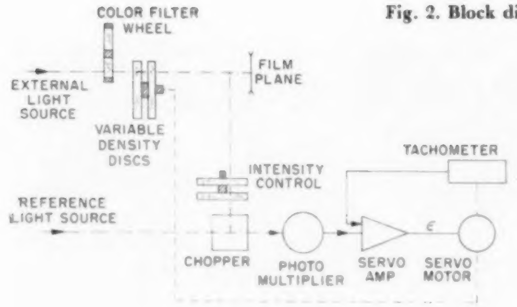


Fig. 2. Block diagram of the autoexposure unit.

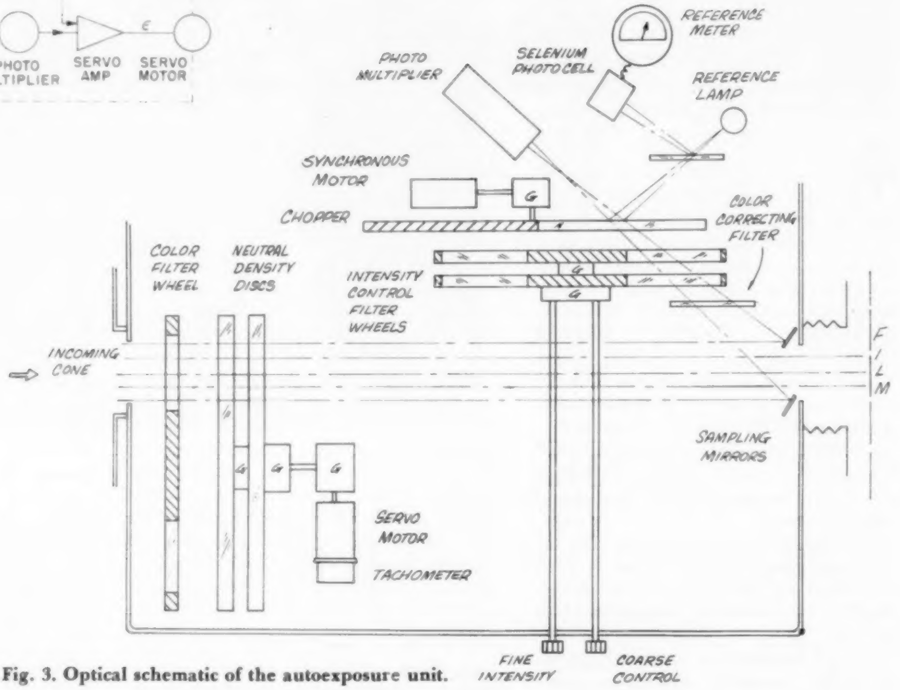


Fig. 3. Optical schematic of the autoexposure unit.

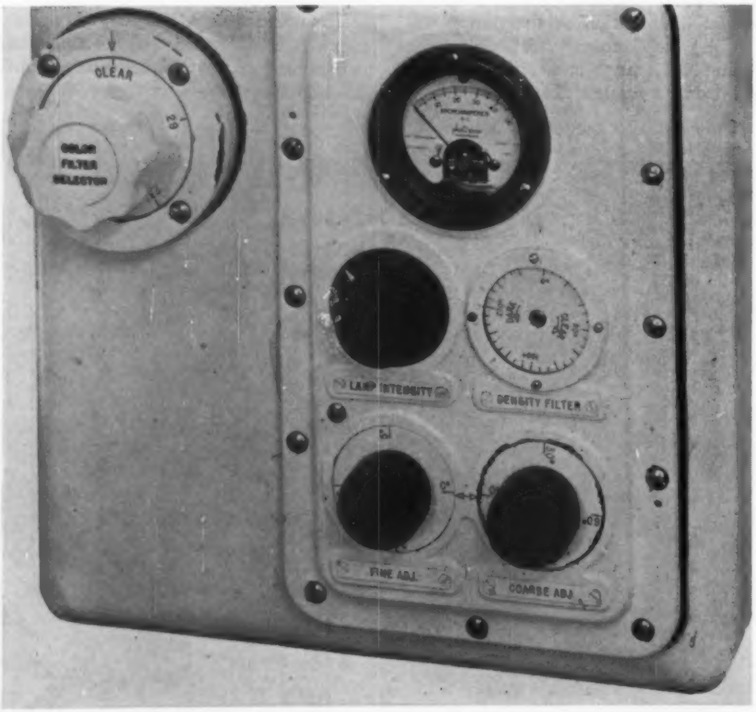


Fig. 4. The autoexposure main control panel.

stat controls this light intensity by varying the voltage to the lamp (Fig. 4).

The S-10 cathode of the photomultiplier does not have the same spectral sensitivity as the film emulsion; therefore, the light from the sampling mirrors is transmitted through a color-correcting filter which matches the sensitivity of the detector to the spectral sensitivity of Kodak Linagraph Shellburst film which is the standard emulsion intended for use in the ROTI Mark II instrument. The filter can readily be changed when film types are changed. Figure 5 is a photograph of the autoexposure unit in its housing.

The detector output voltage is a function of the energy level and wavelength of light; similarly the film density also varies depending on the energy level and wavelength.

The sensitivity set at the autoexposure unit with white light and no filter is defined as 100% response. With a filter in the light path, the spectrum of the light reaching the film and the detector is narrowed and the detector output will not exactly match the response of the film. Table I lists the accuracy of the color corrections when various filters are used, and gives the detector output relative to the film response.

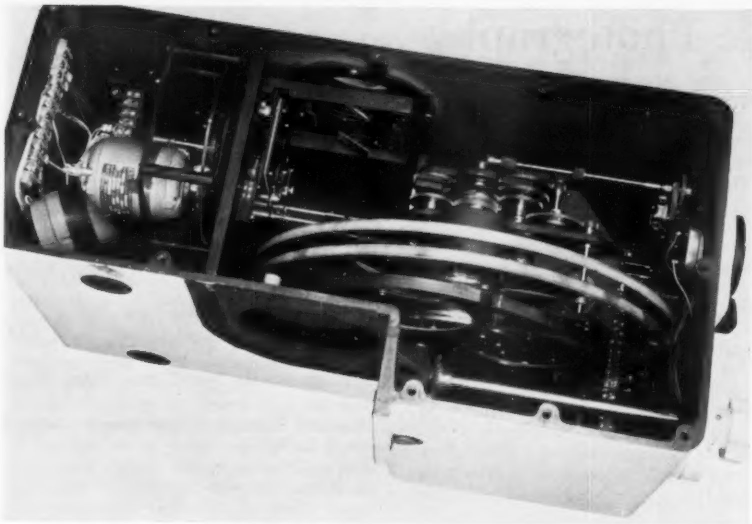


Fig. 5. Arrangement of components in autoexposure housing.

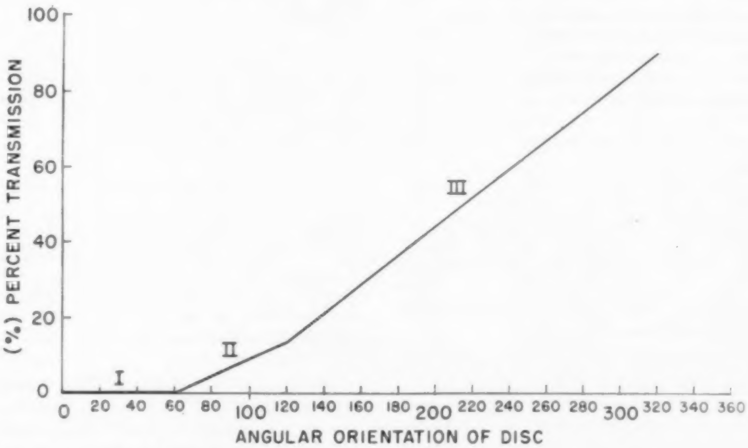


Fig. 6. Variable-density disk transmission curve.

Since the system is designed for use with the 70mm Photosonics camera with shutter openings that vary from 2° to 120° and frame rates of 10 to 60 per sec, the light level at the film plane could vary by a factor of 360. To accommodate these variations of intensity and to allow for the use of films of different speed, a pair of intensity control filter wheels also intercept the light from the telescope objective before it reaches the chopper and photomultiplier. The transmission of these filters ranges in steps of 1.59. Thus the intensity control filters adjust the light level at the film plane over the range of 0.1 to 100 lm per sq m.

The error signal is a voltage which is fed to a servo amplifier where it is amplified to drive a servomotor. The servomotor, in turn, drives the neutral density disks in a direction which reduces the error and tends to make the modified light from the sampling mirrors equal in intensity to the reference light.

The 14-in. diameter neutral density disks transmit from 3% to 100% of the peak transmission of the light entering the telescope objective. In order to maintain a constant light level within the $\pm\frac{1}{4}$ stop accuracy required, a pair of contra-rotating neutral density disks are used. The contra-rotation of the disks in one direction increases the density on each disk, and the transmission through the two is uniform when they are superimposed.

Table I

Telescope filter	Cutoff, millimicrons	Detector sensitivity (white light = 100)
Clear	—	100
8	480	99.1
15	528	88.3
23A	570	94.9
29	610	104.3

Out-of-focus ghost images from the variable-density disks caused some concern. These images occur from internal reflections between the disks, particularly in the high-density regions. Inconel was selected and only 140° of the second disk was coated to reduce the ghost images. The intensity of the ghost imagery is thus limited to a maximum of 2%.

Since the second disk was only partially used both disks had to be designed so that the density curves had three slopes rather than two. The shape of the curve was selected to minimize abruptness of the transition from the clear to the dense portions of the disks within the $\frac{1}{8}$-stop accuracy required. Each has a clear sector, a density coating to give a half-slope sector and another density coating to give a full-slope sector. These sectors are shown as I, II and III in the curve of density vs. angle (Fig. 6).

In operation, a clutch stops the second disk at the beginning of sector III, while the first disk is free to rotate to the higher density portion.

Conclusion

The use of variable-density coated optical glass disks in a null-type system with a reference light results in a stable autoexposure unit without noticeable loss in resolution or contrast. The autoexposure unit with the associated sampling mirrors maintains the illumination at the film plane within ±20% for changes of focal length from 100 to 500 in., and for selection of a wide range of filters and exposure times.

Discussion on Missile Photography

Chairman and Moderator

Sidney M. Lipton, J. W. Fecker, Inc., 6592 Hamilton Ave., Pittsburgh 6, Pa.

Participants

Earle B. Brown, Farrand Optical Co., 4401 Bronx Blvd., New York 70.

W. J. R. Brown, Physical Research Laboratories, Boston University, Boston, Mass.

Walter J. Carrion, Ballistic Research Laboratory, Aberdeen, Md.

J. A. Clemente, U.S. Naval Ordnance Laboratory, China Lake, Calif.

J. E. Durrenberger, White Sands Proving Ground, N.M.

Lincoln L. Endelman, Convair Astronautics, Cocoa Beach, Fla.

Joseph P. Fay, Office of Secretary of Defense, Washington, D.C.

Waldo S. Hunter, II, Ansco, Hollywood, Calif.

Floyd A. Kinder, Naval Ordnance Test Station, China Lake, Calif.

E. P. Martz, Jr., Air Force Missile Development Center, Holloman AFB, N.M.

A. G. Petrasek, Radio Corp. of America, Harrison, N.J.

Herman C. Schepler, Air Force Armament Center, Eglin AFB, Fla.

H. A. Van Dyke, Naval Air Missile Test Center, Point Mugu, Calif.

John H. Waddell, Fairchild Camera & Instrument Corp., 5 Aerial Way, Syosset, L.I., N.Y.

Mr. Lipton: This is the first panel discussion on Missile Photography held before a Convention of the Society. It has been evident for many years that the photography associated with the testing of missiles and similar targets in space is becoming increasingly specialized. The field includes research leading to development of instruments varying in size from tiny cameras to huge missile-tracking telescope installations. The new instruments require infrared devices and electronic accessories, including television equipment, in addition to the familiar components of lenses, cameras and mounts. The complex relationships existing in the atmospheric path from the object to the recording instrument must be thoroughly investigated. Proper photographic emulsions and methods of controlling development are of great importance, and must be carefully chosen. Throughout all this endeavor lies one basic condition of operation: the final result can be achieved by only one attempt — no retakes are possible. It is hoped that this meeting will be followed by many others in which the complete range of problems in this field will be explored, discussed and evaluated.

Mr. Endelman: The effect of atmospheric disturbance on long-range focal-length lenses has not been brought forth with any concrete examples of corrective measures. Can the panel in general tell what is being done in the way of some type of filtering effects or in the actual design of lenses to overcome these atmospheric problems?

Mr. Martz: Several things can be done and have been tried with varying degrees of success. For example, if you elevate a camera station above the layer of heat radiation from the ground, you get improved resolution. This is a standard practice for surveyors who get ten feet above the ground, or higher, on towers if they can.

If you use a shorter exposure time, such as 0.001 sec, or even 0.0001 sec or less, you freeze the small-scale irregular refraction or image blurring that causes the trouble and you get a much sharper image. You may get a very peculiar looking object: a straight line may appear as if broken up into sections because different parts of it are refracted differently, but with exposures of the order of 0.001 sec or less you do get better resolution and less image dilution; therefore you get more range because of increased contrast in the film plane.

Also, you can use long wavelengths, those in the far infrared, since the long wavelength light is less refracted than ultraviolet or blue light. You will, at least theoretically, get less atmospheric blurring effect with long wavelengths, of about 10,000 to 15,000 A, in the optical photographic region.

Mr. Schepler: It should be pointed out that with infrared it is necessary to use much better optical systems to get comparable results on account of the loss of resolution in using the longer wavelengths. Whether you gain or not in going in this direction depends upon the problem at hand.

Mr. Waddell: For the past couple of years at the University of Michigan, studies have been made of sunrise at various times of the year, with a view to selecting sites for astronomical observatories. The studies of the turbulence of the sun, for example, are the most weird and wonderful things that you've ever seen; even at the picture-taking rate of 3000 frames/sec the turbulence is very noticeable on the sun's surface, and it's possible, for example, to get a comparison between turbulence and temperature on the surface of the sun and the surface of the earth.

Mr. Fay: After hearing the comments relative to the effect of increasing lens diameters, can someone tell us the actual fraction of the area of the 200-in. telescope mirror which is usable?

Mr. Martz: The entire surface gives satisfactory results for the purpose for which it was intended, which was as a light gatherer for spectrographic work and for taking photographs of faint stars and faint nebulae. The question of fine detail definition is something else again. There the atmospheric refraction limits quality and, as I mentioned earlier, you might do best with a 20 to 24-in. diameter with an eccentric diaphragm over it, and let the rest of the mirror remain unused. The 200-in. mirror is quite satisfactory for its original purpose of light-gatherer, and not as a fine detail rendition instrument.

Mr. Carrion: We now have an instrument with a 30-in. diameter mirror, 100-in. focal length with which we have gotten very good detail, photographing horizontally at 5 miles. We can even distinguish the branches on trees. We haven't had time to measure this; in fact only this week we showed it to Dr. Schendel.

Mr. Lipton: The point was made earlier this afternoon that the diameter you can use depends somewhat on the geographical location in which you are situated. If you are situated over water or the line of sight is over water, as Mr. Carrion pointed out, you may have less turbulence and less refraction of the air waves to deal with. If you are over ground or hilly country, the result might be entirely different.

I would like to propose a few additional questions for discussion.

Since television equipment is of primary interest to many in our audience, it would be very pertinent to find out what part television can play in these optical instruments.

Then, with regard to photography in satellite tracking, everybody today is interested in the satellite. How about the instruments for photographing or visually observing it?

Next, do we need film emulsions different from those already available, in order to get the best results considering the infrared portion of the spectrum or any other portion of the spectrum?

Will infrared techniques be used more intensively in the future?

And finally, what about aircraft for the use of long focal-length tracking equipment? Can we extend the range of usefulness of optical equipment when there are clouds, for example?

This discussion was held on May 3, 1957, during the Society's Convention at Washington, D.C.

Mr. Carrion: At the Ballistic Research Laboratory our only use of television to date has been in using closed-circuit TV as a guiding scope. The closed-circuit TV has been placed on the tracking telescope in a guiding-scope position, whereby we are enabled to get back a mile or two and track the instrument. This enables the trackers to be out of the impact areas.

Mr. Van Dyke: We, also, have been conducting some experiments, with the assistance of the Denver Research Laboratory, in the use of television as a means for tracking. Our emphasis, however, was slightly different. We were anxious to extend our ability to see a great distance, not necessarily to allow tracking from a remote point.

Unfortunately we found that we were unable to push back the horizon of human vision beyond a given point; that is, assuming a certain optical system was used both as a telescope through which an operator could look and also that a duplicate of that telescope was used with either an image orthicon or a smaller tube and the picked-up information shown on a screen. We were unable to extend a person's vision at the present time, and we decided to await further developments in television tubes. This was in spite of the fact that, regardless of how small the object got, the television screen always was able to produce a finite sized image.

Mr. Petrasek: What orthicon did you use in that experiment?

Mr. Van Dyke: I don't recall the name of the orthicon. We also used two different vidicons with which we were able to get fairly well down into the infrared region.

Mr. Petrasek: Did you try the wide-spaced, low light-level orthicon (RCA, Type 6849), under adverse conditions, such as at night? This instrument was developed about 1½ years ago.

Mr. Van Dyke: No, we could not have, because these experiments were completed about that time. We are hoping that the state of the art is going to catch up on this and that we will be able to go further with it. I understand White Sands is continuing this type of experiment; but at Mugu we've had to drop it temporarily.

Mr. Petrasek: At our Lancaster plant we have improved the low-light-level capability of orthicons and quite recently we have developed an orthicon with a tri-alkali photosurface, which may enable you to accomplish more in the direction you are going.

Mr. Lipton: Mr. Martz, can you tell us about plans for photographing the satellite?

Mr. Martz: There is an article in the January 1957 *Sky and Telescope;* and in the April 1957 *Journal of the Optical Society of America* there is an article on optical problems of the satellite by Tousey of the Naval Research Laboratories. He gives further references and goes into the tracking problems briefly. But I think I would like to refer this to Mr. Durrenberger who is on the Visual Tracking Committee.

Mr. Durrenberger: There are a number of methods in the mill regarding the actual photographing of the satellite, but once again I think we're going to learn a lot before we're through with the project. The first thing, of course, will be to get the satellite up where it is going or where it is supposed to go. After that is accomplished, the first basic tracking method on which they are depending is, of course, the Navy Research Laboratory's Minitrack system. This is, in essence, a beacon-type unit in which a phase relationship measurement is taken in varying degrees of fineness down on the ground. The angular aiming of the Minitrack antenna system itself is to be calibrated in conjunction with the narrow-angle ballistic camera which has a focal length of approximately 40 in. A flashing light system on an aircraft is to pass through the approximate region in which the Minitrack is expected to operate. The Minitrack stations are favorably deployed for the particular problem.

In order to get as close to real-time data as they can, the flashing light on the aircraft is actually going to be coded in conjunction with WWV time signals in such a way that you will read sidereal time directly and come up with final data in terms of right ascension and declination from the individual stations. This is getting away from the actual photography of the satellite itself.

The information from the Minitrack stations and other sources will be gathered and sent to the Electronic Computer Center at the Smithsonian Astrophysical Institution in Cambridge, Mass. This information is to end up in a rather rough orbit calculation which, in turn, will be relayed to the various IBM Computer Centers or Nunn-Baker Schmidt-type camera stations. These contain a Nunn-Baker Schmidt-type instrument which again is being distributed in locations favorably deployed around the expected orbit. Fortunately, one of these stations is going to be right in our backyard at White Sands. There was a complete write-up on the Nunn-Baker Schmidt in *Sky and Telescope.*

The people who are going to operate this unit tell us that they expect to cooperate very closely with us who are in the amateur visual observers' groups also scattered through the world. As a backup, and quite frequently backup instrumentation turns out to be prime, we are setting up, on a completely volunteer basis, groups of visual observers with comparatively wide-field, low-magnification telescopes, comparable to a rich field telescope, aimed along the meridian so that observers will actually have overlapping fields. We intend to cover an area from about 45° of declination from our Zenith in both directions. The expected magnitude of the satellite, if it is in the predicted orbit, has been variously mentioned as 5.6, 6.2, 6.3 and out to beyond 9th magnitude, which we cannot expect to get by the limited light-gathering capability of the so-called Moonwatch scopes. These are essentially nothing more than a telescope which will give a 12° circular field with a 5½-power magnification, arranged so that in the 12° field you can circumscribe an 8° square in such a manner that the successive observers have a ½° overlap in their respective fields.

Should we detect a satellite, which of course would be going at a very rapid angular rate, there will have to be a minimum time delay in order to alert the crews, since the Nunn-Baker camera from the Smithsonian will be only about 15 airline miles east of us.

However, we expect to be able to transmit information by radio, giving the approximate declination and right ascension of the satellite as we spot it. We, of course, are rigidly oriented along the meridian. The Nunn-Baker's are in equatorial mounts so that they will have tracking capability. Since the expected approximate angular velocity is known, if we give them an indication of what the declination will be, they will then start with their very wide-angle unit. Radio will be the quickest way we will be able to alert the local group. Any hope of detecting it by any of the normal satellite-detection means, such as Prof. Tombaugh has perfected in his work for the Office of Ordnance Research, is unlikely because of the very high angular rates and the fact that the satellite is only going to be visible from the earth during periods of twilight — before sunrise and after sunset. This means that there is a good chance that there will be considerable skylight background during the period of transit, which will make photography extremely difficult on a random search basis.

Mr. Lipton: What does the panel think about the need for different kinds of emulsions on film compared with what now exist?

Mr. Clemente: The tremendous increase in film speeds that has occurred in the past five years, both in black-and-white and color emulsions, has certainly alleviated a lot of our difficulties. We've been very gratified to see these increases.

Mr. Hunter: There is a new material just being readied for release in long lengths for theodolite use. It's known as Super-Anscochrome and has a nominal speed of 100. Apparently installations like NOTS are using regular Anscochrome in their theodolites at a speed of 125, which badly aggravates grain, does not help out definition, etc. This new material gives results quite comparable at 100 to regular material at 32. This will help, but we're quite confident that users like NOTS will be using a speed of around 400, so we will be right back where we were. I believe that these speeds of 400 will allow them to use either smaller lens diameters or shorter exposure times; either one or both should help this definition problem.

Mr. Durrenberger: Optically and mechanically, we are very rapidly approaching the ultimate for our optical capabilities with reference to ballistic cameras.

I doubt, however, that we have yet reached the ultimate for emulsions, which are what we are actually measuring in getting our final data. Quite frequently, as we go to higher speed emulsions, not only do we get a coarser grain, but in order to cover the spectral sensitivity that we desire together with high speed, we end up with thicker and thicker emulsions.

Within a very short time we are going to have available comparators which will consistently be able to read out to a micron

and which will have automatic digitizing devices capable of transmitting information or recordings good to $\pm 2\ \mu$. Now in order to make full use of the capabilities of the tools we are getting, I believe we are going to need thinner and thinner emulsions which should, in turn, be subject to less randon emulsion shift. Right now, random emulsion shift actually does not match the precision which the other components have achieved.

Mr. Clemente: Greater speed also is a help in the area which was discussed earlier. We have found that in the Bowen cameras, where we use a mechanical rotating drum shutter, the blurring of the image due to refractive disturbances in the atmosphere seems to disappear very rapidly as you get below 100 μsec exposure. We can very definitely notice the difference in the blurring of the image of a fixed object such as a telephone pole. There is considerable difference between a 20-μsec exposure and a 100-μsec exposure, which indicates that the heat waves or shimmer produce complex waves which include frequencies that run up in the neighborhood of 5 kc or higher.

Mr. Van Dyke: I'd like to return to what I spoke about earlier — in the hope that there are others interested in the availability of high-speed tracking equipment at this time. At Point Mugu we have four tracking mounts which we call Motu's (mobile optical tracking units). Each is capable of angular velocities of about 60°/sec and angular accelerations of about 60°/sec squared. These mounts also are capable of carrying a camera load of about 300 lb. At the present time we have a 70mm Mitchell and a 35mm Mitchell on the mounts and the 70mm is equipped with a 300-cm focal-length lens, and the 35mms are equipped with 60-cm focal-length lenses. There's space available, if necessary, for another camera to be mounted. These instruments photograph azimuth and elevation scales with about the same general range of accuracy that the Askanias have, and have just been turned over to operational service.

Five more of these instruments, but this time without the actual scales, are planned, three to go to Patrick and two to NOTS annex in Pasadena.

Mr. Endelman: What do you suggest when the tracking rate can be extremely slow but the error should be only one to two seconds of arc?

Mr. Van Dyke: Accuracy to within 1 sec of arc, which is 1 ft at 40 miles, is more than we can hope for at present.

W. J. R. Brown: With respect to the film sensitivity problem which was discussed a few moments ago, we are completing a fairly extensive study of atmospheric optics at the AFMTC range. An experimental film has been obtained for this use from Eastman Kodak Co., labeled Special Order No. 1166, but, of course, available to anyone. This may represent the prototype of an aerial film called Kodak Plus X Aerecon Film (Eastman Kodak Co. states that this film is now available). In our laboratory and field tests this film has been found to be roughly comparable in graininess and resolution to the present Kodak Linagraph Shellburst Film which represents some sort of standard in the field of aerial missile photography. The new film has perhaps a little lower gamma, but it has the advantage of some four times the speed. Although in many cases this speed is of no particular advantage since the optical systems are perfectly capable of operating satisfactorily with what is available, in other cases this film would perhaps represent a real advantage. In our extensive laboratory and field tests it has been found acceptable in all ways, if the slight loss in gamma, in the neighborhood of 20%, can be tolerated.

Mr. Clemente: In some of our work we are using black-and-white film in the 25 to 75 times underexposure region where we find that the normal film-speed ratings, which are made for the more linear portion of the H&D curve, don't have much meaning for us. Actually we are more interested in the shape of the toe of the curve than anything else in this particular area, and this is something that we find is not generally known. We find it very difficult to get any information about films unless we can actually take them out and use them.

W. J. R. Brown: These speed evaluations were made on that basis, not on the basis of the conventional ASA speed index which, as you say, has virtually no meaning in this particular case. This particular film performs very nicely indeed in the underexposed region.

Mr. Lipton: Will infrared techniques be used more intensively in the future in the type of work which we have been discussing today?

Mr. Schepler: Using infrared may not help as much as would sometimes be expected. In our use of infrared, for example, we have made a coordinate cell for measuring tracking offset, or what is sometimes erroneously called tracking error, using lead sulfide on a glass plate. This plate is put in the camera in place of the film. We are using it on a Contraves cinetheodolite. The system provides an angular position of the target with respect to the camera to ± 0.1 mil.

In land and airborne tests of this device, we have obtained some improvement in range over our photographic method. Tests that have been made on other ranges and by some commercial organizations have shown equal or better results in the yellow and red regions of the visible spectrum than in the infrared.

At the Air Force Armament Center we are constructing an infrared target range for measuring airborne infrared detectors. Either heating coils or hot water pipes in a strip of blacktop pavement, 450 ft long and 150 ft wide, will make it possible to turn heat on and off to get various widths of hot strips and adjacent cold strips, thereby providing a resolution chart for infrared testing. By flying over this strip with an infrared detector we will be able to measure the resolution, the sensitivity and the detectability of the infrared detector.

Mr. Kinder: We have found, working with various types of detectors for tracking error or offset, that the main difficulty is with signal-to-noise ratio rather than angular resolution as no beacon is permitted on the missile. It is necessary to determine automatically which is the target in respect to the noise background. This requires a better signal-to-noise ratio than if there were a human operator there to decide. We are working with various methods of space filtering, frequency or wavelength filtering, tuned amplifiers, and television methods of improving contrast, each of which improves the signal-to-noise ratio.

Mr. Petrasek: Depending on the ways you are using the infrared detectors, it may be of interest to note that there are available some gold-doped germanium infrared detectors which will probably go out into the far infrared, to about $10\ \mu$.

Mr. Schepler: That is of great interest. Even though we are doing no development in this field, we are interested in the infrared detectors available and being developed commercially. At present, we are planning a program at Patrick AFB with a type of detector system for tracking missiles similar to the one I previously described. There is really a fine, hot infrared source in the tail end of a missile, which is ideal for tracking. This appears to have good possibilities for achieving good range, which we have not been able to achieve with the coordinate-cell system. This was partly because we had to put a pulse infrared source on our target, and it turns out that a large aircraft is needed to carry a source large enough to get any appreciable range. This is a definite limitation. We expect to get considerably more range when we run these tests on missiles at Patrick.

Earle B. Brown: Could Mr. Schepler advise us what is the color temperature of the infrared sources that he has been using?

Mr. Schepler: We have been using a pulsed source developed at MIT, but I cannot tell you offhand the color temperature of this source. We are investigating missile rocket plumes from this standpoint and we expect to determine the spectral distribution of the energy and to locate hot spots in the plume. If you cannot locate a hot spot, the resolution will be considerably less. If we can detect hot spots in the plume it will mean that we can position the missile much more accurately.

Mr. Lipton: What is the feasibility of using aircraft as a mount for optical tracking equipment of moderate or long-focal-length lenses?

Mr. Van Dyke: We have been successful at Point Mugu in taking stationary camera pictures, in an airborne situation, with lenses as long as 40-in. focal length.

W. J. R. Brown: In the Physical Research Labs at Boston University, we have considered the problems of airborne surveillance for targetry. Our particular field of interest is not that of theodolite angular measurement, but simply of surveillance photography. With our ground measurements, using equipment at Patrick, we

found that with an $f/10$ 20-ft focal-length system we were obtaining resolution from the ground of airborne targets at roughly between 10° and 30° elevation, running from 8½ microradians down to approximately 50 microradians, largely as a function of the differential refraction or heat shimmer which was apparent at the time.

In the course of the study it became quite apparent that if things are to be seen at a considerable distance, you need considerably better than 50 microradians. Consequently we embarked on a feasibility program, at least in terms of what can be done with an airborne camera station. We feel that, based on experience with long-focal-length optics stabilized in gyromounts, etc., such a system could very well be described which would attain somewhat better than 8 microradians at all times with focal length up to 20 ft.

Letter to the Editor:

Magnetic/Optical Stereophonic Sound

These comments are in reference to the Discussion published on p. 763 of the December 1957 *Journal*, at the close of the paper "Further Data on Infrared Transparency of Magnetic Tracks," by George Lewin, which was presented at the Society's Philadelphia Convention with a demonstration of stereophonic sound from a magnetic/optical film. In relation to the information set forth by Dr. Frayne and Col. Ranger in the discussion of Mr. Lewin's paper, these comments are submitted on the basis of the technical work done at Telefilm, Inc., facilities to produce the stereophonic demonstration film, when it was my privilege to work closely with Col. Ranger in the technical production of this film.

When these experiments were started, we realized, as Dr. Frayne pointed out, that magnetic and optical are two radically different methods of recording. This in itself does not, of course, mean that the two systems cannot be aurally matched. Disk recording and tape recording are quite different, yet with equipment developed in the last few years, we can now produce a disk recording virtually indistinguishable from its original tape, even when compared under the most critical conditions.

Similarly, we in the 16mm film industry now have available to us new recording galvanometers, new emulsions, and automatic controls over processing and printing, so that we are now making tracks on 16mm release prints that would have been considered adequate for 35mm only a few years ago. Projection equipment is constantly being improved to take advantage of these better tracks.

At the present stage of the art we have little difficulty supplying a 16mm release print track with essentially flat response from 75 to 7000 cycles, and a number of experiments have been conducted demonstrating the possibility of extending the range even further. (I believe Mr. John Maurer has been quite active in these experiments.) Intermodulation and harmonic distortion are still with us, but with modern quality control methods in developing and printing, along with the new recording galvanometers, we are getting quite good results in our attempts to get lower distortion readings. I won't say they are as good as we would like to have them, but, for instance, we can hold single sine wave distortion in the mid-frequencies to about 5%. This certainly leaves room for improvement, and yet, unless you play the track on a very good speaker and in a dead room, you don't hear the distortion at all. Cross-modulation distortion is not a serious problem. With good processing and printing control the cross-modulation distortion on variable-area recordings can be kept well below audibility. I believe most people in the industry are getting about a −38 to −40 db, using the standard test procedures, which is quite adequate.

With magnetic sound primarily in mind, there is no practical reason why the magnetic frequency response cannot be limited to match whatever is available on the optical; and for that matter, we could deliberately introduce a little noise and distortion into the magnetic in order to better match the optical. So I think if we proceed from the standpoint of getting the best possible optical and then matching the magnetic track to it, there is no reason why we cannot get a very acceptable match between the two. I might add parenthetically at this point that since the two tracks are normally played at a lower level when used together than if either was used monaurally, the inherently higher noise level of the optical track is quite a bit less apparent.

An additional advantage of the optical magnetic combination over a system using two magnetic tracks lies in its compatibility. The fact that this is only a two-channel system makes it feasible to use only one track if necessary, in the same way that one can listen to only one side of a two-channel radio broadcast and still hear an acceptable program. Compatibility is going to be a big issue if 16mm stereo is to become accepted production technique. The use of an optical track covered with a halftrack magnetic stripe would allow the print to be played on any 16mm sound equipment presently in use, while machines equipped with lead sulfide cells could play the additional optical track under the magnetic, with corresponding improvement in output and signal-to-noise ratio.

Steven A. Guy
Telefilm, Inc.,
6039 Hollywood Blvd.,
Hollywood 28

From John A. Maurer

In response to the request to review the comments:

I agree in general with what Mr. Guy has said, but it should be pointed out that he has understated the case as to the quality that can be obtained with 16mm optical sound. During the past few months, I have made a large number of tests by re-recording from ¼-in. magnetic tape records to 16mm release prints using the linearity-compensated variable-density system which I described at the Philadelphia convention, with a frequency response flat to 11,000 cycles. The results have been pleasing even when played in direct comparison with the original tapes.

When properly designed, wide range recording equipment is used, the only really noticeable difference between magnetic and photographic records is the higher background noise of the latter. As film is generally processed in the industry, this difference is of the order of 15 db. Most of the noise of the photographic track, however, is due to suspended matter picked up by the film from the processing solutions, the wash water, and the air used for drying. Photocell hiss and the noise due to the

grain structure of the image are *at least* 10 db lower in level than this noise due to dirt accumulated during processing. If it were considered necessary, therefore, to produce photographic tracks very nearly as quiet as magnetic records, this could be done merely by doing an unusually careful job of filtering the developer, fixing bath, wash water, and air used in the film laboratory.

March 27, 1958

JOHN A. MAURER, President,
JM Developments Inc.,
116–118 W. 29 St.,
New York 1, N.Y.

From George Lewin

I greatly appreciate Mr. Guy's comments and welcome the opportunity to acknowledge his contribution to the preparation of the stereophonic demonstration film which accompanied Col. Ranger's and my own presentation at the 82d Convention on October 8, 1957. The credit was recorded on the film but I regret that I neglected to include it in the published version in the December 1957 issue of the *Journal*.

Mr. Guy is certainly correct when he states that it is feasible today to obtain excellent frequency response and low distortion on 16mm prints with optical soundtracks. The regrettable thing is that so many producers do not consider it worth the added expense for equipment and personnel to achieve and maintain optimum quality. The great need is for better printers and constant vigilance to keep exposure, processing and projection within the necessary narrow tolerances. If the proposal to make stereophonic recordings by combined optical and magnetic tracks stimulates the need for better control of optical sound quality in order to match magnetic sound quality, that alone should make it worth while.

The advantage which Mr. Guy points out regarding the compatibility of the optical-magnetic combination is a very good one. Still another advantage derives from the complete absence of crosstalk between the two channels. This is something which will be impossible to achieve in an all-magnetic system because of the necessary close spacing of the heads if both tracks are to lie within the area now occupied by the optical track. Because of the fact that the magnetic halftracks would probably have to be considerably less than 50 mils wide, it is likely that their signal-to-noise ratio would be inferior to that of a good optical track even when completely covered by a magnetic track and reproduced with a good lead sulfide cell.

Incidentally, I should like to acknowledge the assistance which is being given me by the Bell & Howell Co. and the McKay Research Laboratories in my quest for improved photocells which will still further improve the infrared transparency of magnetic tracks.

March 31, 1958

GEORGE LEWIN, Chief,
Pictorial Engineering Office,
Army Pictorial Center,
35-11 35 Ave.,
Long Island City 1, N. Y.

Editorial Note

Mr. Guy has requested that comments, suggestions and questions be referred to any of the following:

STEVEN A. GUY,
Telefilm, Inc.,
6039 Hollywood Blvd.,
Hollywood 28

GEORGE LEWIN
1573 E. 35 St.,
Brooklyn 34,
N.Y.

Col. RICHARD H. RANGER,
Rangertone, Inc.,
73 Winthrop St.,
Newark 4, N.J.

Errata

William S. Halstead, "The NARCOM Plan for Transatlantic Television and Other Wideband Telecommunication Services," *Jour. SMPTE, 67:* 134–138, Mar. 1958.

On page 134, column 3, line 6 of paragraph 2, *read:* 1951 *for* 1950.

On page 135, column 3, 5th line from the bottom, *read:* . . . at about 22 dba at zero level *for* . . . at about 22 db, etc.

For Reference 6 on page 138, *read:* K. Bullington, "Radio transmission beyond-the-horizon in the 40- to 4000-mc band," *Proc. IRE, 41:* 132–135, Jan. 1953.

Due to the author's isolation by snowstorms on a field trip, the final manuscript and proofs regrettably could not be reviewed before publication of the group of papers on international television.

Anamorphic Television Circuit Requirements

By MADISON CAWEIN

This paper discusses theoretical circuit requirements for anamorphic television,[1] producing a wide-screen image (high aspect ratio) at the receiver. The relation of aspect ratio to pictorial information as regards frequency band, defined by the first elided frequency, is discussed. Pictorial information is defined in terms of contrast and resolution. The anamorphic squeeze and unsqueeze are described. Low-noise video and novel EIA timing circuits are shown.

The literature is replete with derivations[2] of TV bandwidths required to transmit images. A résumé of one method of deriving the TV band will be given in order to indicate the important factors. The references can be consulted for details.

The television method employs "area" scanning of the image to obtain an electrical signal in which there is a one-to-one time correspondence between signal amplitude and the illumination of minute areas, spread out in a predetermined time sequence. A minute area (picture element) is called the "spot size," which may be a hole through which light from the area is observed (mechanical system) or the area of an electron beam used to discharge a photoelectric plate on which the optical image is focused (electrical system).

The ratio of the area of the image to the area of the spot is a measure of the (pictorial) information obtained and transmitted. This ratio is the number of picture elements, representing part of the "bits" of information. The electrical signal obtained from scanning two separated illuminated areas (thin bars) of the order-of-size of the scanning spot, shown spread out in time on an oscilloscope when the spot (Fig. 1 (A)) moves along the scanning path (line), would appear somewhat as in Fig. 1 (B). Here the first bar has twice the intensity of the second.

Fourier analysis gives the frequency components of the pulse shapes (b). The analysis is based on scanning one bar (a) during one line of each frame at F scans per second. A finite spot is assumed. The amplitudes are as in Fig. 2 (a) or, if by an infinitesimal spot, as in Fig. 2 (b). Actually, the act of scanning by an infinitesimal spot gives rise to groups of components whose amplitude envelope changes polarity at every multiple of f_c. These multiples are known as elided frequencies, or frequencies of zero amplitude, f_c being the first elided frequency. The significance of f_c is that the degradation of frequencies due to aperture size can be compensated almost up to f_c by an aperture-equalizing amplifier having a gain characteristic whose shape is the ratio of envelope (b) to envelope (a).

The finiteness of spot size broadens the base of the pulse from a picture element of a width equal to spot size; that is, it degrades the higher frequency components just below f_c, and eradicates elements of $\frac{1}{2}$-spot width, by integration, making the components above f_c negligible according to the $\sin^2\theta/\theta^2$ function. $\theta = mr\pi$, where m is the order of harmonic; and $r = 1/AN^2$ is the ratio of bar width to total length of scan path, or of spot area (square spot assumed) to area of the unblanked scanning raster (framed image).

Aspect ratio enters the first-elided-frequency formula

$$f_c = AN^2F \qquad (1)$$

by virtue of the area of the image expressed in units of line width: raster-area/spot-area $= HW/\text{unity} = N \cdot AN = AN^2$.

Information theory[3] indicates that the product of time and frequency band is required for the transmission of information. The information consists of picture elements (resolution) with various light intensities (contrast). The tonal gradations (contrast range) within the resolved areas contribute to the information according to the logarithm of the range, as first deduced by Hartley. More specifically, Shannon[4] has indicated that the information transmitted is proportional to a function $C = \log_2 (s/n + 1)$, where s/n is the signal-power to noise-power ratio. When this ratio is unity, the value of C is also unity.

Experimentally, it was determined by the author about 1945* that for $s/n = 1$, a pin-point of light could just be detected on a dark photocathode in a Farnsworth dissector. The pin-point was a 0.002 in. circle of parallel light on a 2-in.-wide scanned-raster. The level of illumination was raised until a wide-band scope showed the voltage of the video signal pulse from this pin-point to

*Farnsworth Research Dept.

Presented on October 9, 1957, at the Society's Convention at Philadelphia by Madison Cawein, Grimson Color, Inc., 381 Fourth Ave., New York 16.
(This paper was received on September 23, 1957.)

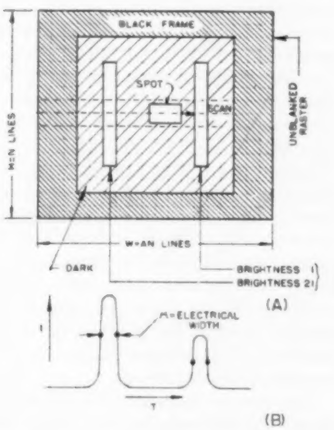


Fig. 1. Picture-element signals from illuminated bars (illuminated once each frame during time of scan of central line only).

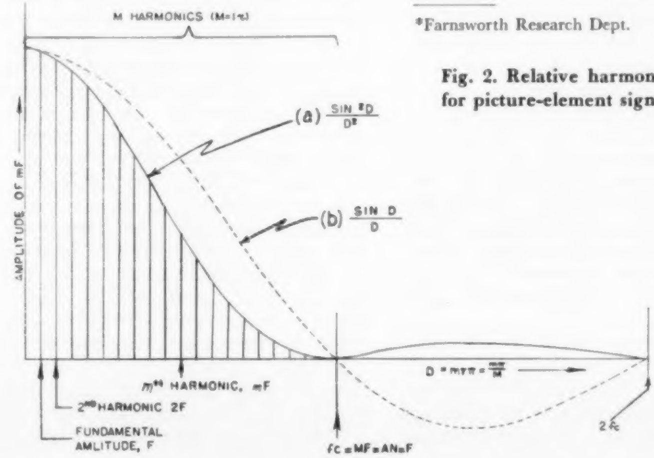


Fig. 2. Relative harmonic amplitudes for picture-element signals.

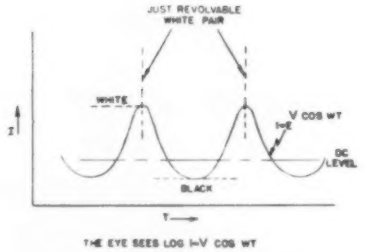


Fig. 3. Electrical video signal for proper observation (logarithmic eye-response assumed).

be about 50% higher than the noise-voltage background. Observers were able to locate the "spot" with some certainty on a TV receiver screen. This experiment established that a value s/n of approximately unity was a just-discernible contrast step.

It will be appreciated that resolution is not observable without discernible contrast. In 1933 it was determined by E. W. Engstrom and other RCA workers[5] that 0.7 N lines of equal H and V resolution could be observed in a TV chart transmitted in a frequency band B, where:

$$B = 0.35AN^2F \qquad (2)$$

It is here interpreted that the true meaning of these experiments and theories is this: if the frequency band be widened by a factor 1/0.35 (to $f_c = AN^2/F$), then the total information will be increased by 2.86. This can be perceived either as an increase in *horizontal* resolution to a value $0.7 \times 2.86\ N = 2N$, or an increase in discernible contrast steps to $s/n = 7$ ($\log_2 (s/n + 1) = 2.86$) in $0.7N$ regions of each line, the product of the number of picture elements by the observable tonal gradations therein being the total number of bits of information transmitted per second.

It is generally valuable to approach a problem from two points of view, in the interest of consistency. Basic TV-band formulas, such as (2), were developed from the viewpoint that a sinusoidal variation in voltage is required in the resolved regions of the picture, the plus and minus values of the sine peaks representing a white-black line pair so that the frequency of the highest component is roughly proportional to one-half the number of picture elements observable along a line. This is in keeping with Nyquist's[6] original thinking regarding the minimum band needed to transmit a number of independent quantities in telegraphy.

Actually, since the eye sees logarithmically, the form of the video signal, instead of sinusoidal, should be $e^{\gamma \cos \omega t}$. Then the eye will see $\gamma \cos \omega t$ which is sinusoidal in form, with a

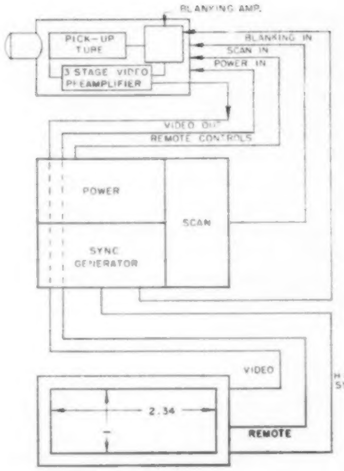


Fig. 4. Essential circuit components.

contrast-range factor, γ. This wave is plotted in Fig. 3. A Fourier analysis of this wave shows frequency components of at least 3 ω; or substantially as for Fig. 1, indicating that contrast information requires additional bandwidth.

Choice of Wide-Screen Standards

It was decided at the outset of the wide-screen TV development to work within the framework of EIA (Electronics Industries) commercial TV standards, except for aspect ratio. An anamorphic factor of 2 was chosen to be in keeping with wide-screen motion-picture practice. Initially, the 4:3 aspect ratio of the camera scanning raster was maintained.

With an anamorphic squeeze of 2, the aspect ratio of the unsqueezed image must be 8:3, which requires that exactly twice the information of a normal 4:3 TV picture be transmitted. Thus, the bandwidth of the video amplifiers had to be expanded also by a factor of 2 (by Hartley's Law) in order that the horizontal resolution not be degraded.

According to the experimental formula (2), a bandwidth of 4 mc is required for 370-line TV resolution, with EIA standards. Thus, it became necessary to provide at least an 8-mc overall video bandwidth, but in order to upgrade the contrast in the detailed regions, 10-mc was actually provided. The first elided frequency of the camera is at 11 mc. Some aperture compensation was provided up to 90% of this frequency.

In the reproduced TV image, it was possible to discern just 800 lines in an EIA chart, with anamorphic lens removed. With the anamorphic lens in place, of course, 400 lines can be resolved in each of two charts side by side, which meets the system requirement.

The anamorphic lens squeezes according to the angle (and not the tangent of the angle).[1] Since deflection angles in TV circuits are approximately linear

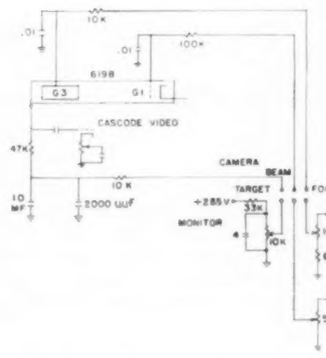


Fig. 5. Remote controls.

with the deflection currents, no special unsqueezing circuits were required: either the horizontal angle can be increased by 2, or the vertical angle can be reduced by 2. The latter alternative was chosen because wider cathode-ray tubes were not available.

A novel and stable EIA standard synchronizing generator was developed to improve the interlace and vertical resolution.

Since the CinemaScope aspect ratio for mag-optical sound is 2.34, the camera scanning-raster can be set at 1.17 aspect ratio, the receiver expansion maintained at 2 and the TV wide-screen standard can be made compatible with CinemaScope. This again allows a slight improvement in vertical resolution because the height of the optical image on the vidicon can be increased from 0.375 in. to 0.407 in., to stay within the 0.625 in. image diagonal allowed. The corresponding receiver raster is approximately 8 in. by 18.5 in. on a 21-in. tube.

Circuits

The essential circuit components are shown in block form in Fig. 4. Power and scan are conventional for the vidicon tube and the monitor, except as to aspect ratios which can be set up at 1.17 on the camera and 2.34 on the monitor by means of the H and V size controls. The cable length between the power chassis and camera is 25 ft. This cannot be changed as it will affect the scan linearity.

Remote control of target, beam and electrical focus are brought out from the camera, through the power unit, and to the monitor. (There is provision for remote optical focus at the monitor, also.) The remote leads are d-c, as shown in Fig. 5. Camera video is also brought through the power unit, to the monitor. This is on 50-ohm coaxial cable at a 0.2-v peak-peak level.

The camera preamplifier is a conventional 6BK7 cascode, feeding a 6AH6 pentode stage and 6U8 pentode stage in cascade. Plate loads are 2000 ohms each, series-shunt peaking. The 6U8 has a conventional high-peaking RC network in

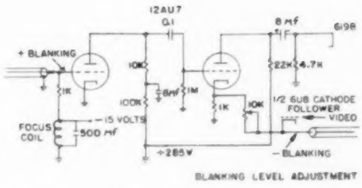


Fig. 6. Blanking amplifier.

the cathode to compensate the 47,000-ohm load resistor in the vidicon target. The triode section of the 6U8 is utilized as a conventional cathode follower, except that blanking is injected on this cathode.

Blanking from the sync generator is applied in positive polarity to the blanking amplifier, as in Fig. 6. This is a 12AU7, two stages in cascade. The output-tube plate signal blanks the vidicon cathode and the output-tube cathode is tied to the cathode follower. Blanking injection is negative in the camera output to give conventional EIA polarity on the camera output cable. This unconventional method of blanking was devised to minimize the number of video amplifiers. The overall rise-time is roughly proportional to the square root of the total number of video amplifiers, and it was desired to keep it to a minimum. The gain of the camera is approximately 80, including a 20:1 loss in the high-peaker and a 3:1 loss at the cathode follower.

There are three conventional pentode amplifiers in the monitor: a 6AH6, 6CB6 and 6CL6. The plate load of the 6CL6 is 2400 ohms. The overall bandwidth is in excess of 8 mc. Partial aperture compensation is provided by an RC network in the 6CL6 cathode.

The synchronizing generator is a two-stage high-count-down design, shown in Fig. 7. A crystal-controlled transistor oscillator provides about 1 v. of 31.5 kc signal to the grids of two buffers. One of these synchronizes a 2:1 count relaxation oscillator for horizontal sync; the other, a 25:1 count relaxation oscillator. The 25:1 count is applied through a second buffer to count 21:1, which produces a 60-cycle vertical sync pulse. The oscillators are designed to develop about 225 v of sawtooth on the discharge cathode so that there will be 8 or 10 v difference on the discharge curve between the occurrences of successive timing pulses. Significant waveforms in the oscillator are indicated in Fig. 8.

Performance Characteristics

A wide-screen closed-circuit television system and circuits have been developed to reproduce by electrical means a scene with 2.34 selected aspect ratio. A squeezed CinemaScope film can be projected directly on the camera tube faceplate, by means of a continuous projector, or an anamorphic Scanoscope

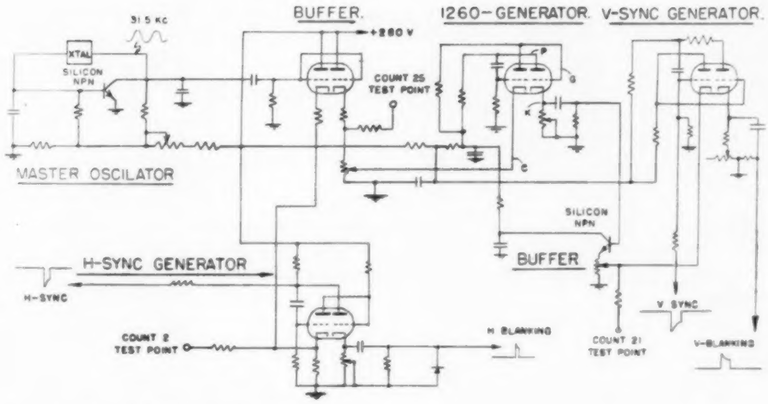


Fig. 7. Synchronizing generator circuit.

lens can be used to select the scene. The reproduced image is 18½-in. by 8 in. at present, on a 21-in. cathode-ray tube; or a TV projection monitor can be used if a larger picture is desired.

The overall horizontal resolution is twice that provided by commercial TV, or about 750 lines, and the vertical resolution is about 375 lines. The contrast is good in the detailed regions of the picture, so that no more information is lost in the wide-screen presentation than would be lost in a standard telecine presentation. The actual TV information is doubled.

Circuitry is simple and dependable. There are 5 tubes in the camera, 17 tubes and one transistor in the power-scan-sync chassis, and 13 tubes in the monitor. A total of 36 tubes comprises the system, including amplifiers, rectifiers and cathode-ray tubes. The power consumption is about 250 w.

Acknowledgment

Grateful acknowledgment is made to Robert N. Geer, Grimson Color, Inc., for design, construction and adjustment of the video amplifier.

References

1. Seymour Rosin and Madison Cawein, "Wide-screen television," *Jour. SMPTE, 66:* 404–406, July 1957.
2. Donald Fink, *Television Engineering*, McGraw-Hill Book Co., New York, 1952, Bibliography, p. 71.
3. Initiated by R. V. L. Hartley, "Transmission of information," *Bell Sys. Tech. J., 7:* 535–563, July 1928, and summarized by Pierre Mertz of Bell Telephone Laboratories in a paper, "Information theory impact on modern communications," delivered on June 24, 1957, before the AIEE in Montreal.
4. C. E. Shannon, "A mathematical theory of communication — Parts I and II," *Bell Sys. Tech. J., 27:* 379–423, July 1948; 623–656, Oct. 1948.
5. E. W. Engstrom, "A study of television image characteristics," and "An experimental television system," *Proc. I.R.E., 21:* 1631–1651 and 1652–1654, respectively, Dec. 1933; ibid., "A study of television image characteristics, Part II, *ibid., 23:* 295–310, Apr. 1935.

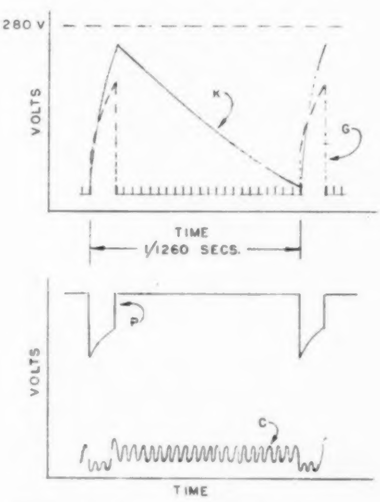


Fig. 8. Sync generator waveforms.

6. H. Nyquist, "Certain factors affecting telegraph speed," *Bell Sys. Tech. J., 3:* 324–346, Apr. 1924.

Discussion

Albert M. Kane (Al Kane Productions, Inc., Philadelphia): To what extent has research been applied in the making of high-quality Hollywood-type pictures using television techniques and television high-quality electronic cameras?

Dr. Cawein: We have done no research in that direction except to run one film through our system, a "squeeze" film part of *The King and I*, and we considered the reproduction to be very good. We used a continuous-motion projector for this, and our projector was not of the best quality. The reason for using a continuous-motion projector was to avoid the necessity of synchronizing the two systems on a pulldown projector. We have not used this system too much for motion pictures; however we have borne in mind that it could be so used. We think that as a closed-circuit television it has more application to industry where it's desirable to see more in one direction than it is in another. That is, 4:3 aspect ratio is pretty limited — the eye sees about 120°. With the anamorphic lens that we're using we see 80° in the horizontal and approximately 30° in the vertical; however, this was on the basis of an aspect ratio of 2.66. We've recently changed our equipment to have the same aspect ratio as CinemaScope, which is 2.34. The quality of the 61mm motion pictures is very good.

Design and Construction of a Motion-Picture Production Sound Stage

By JAMES A. LARSEN

Many features of the design are adaptations of ideas incorporated in other studios, but in the combination and arrangement of the components of the design there are elements of originality which may influence the construction of future sound stages.

THE FIRST step in the construction of the new Academy Films sound stage was to visit typical sound stages at various motion-picture studios in the Los Angeles metropolitan area for the purpose of collecting ideas on studio design and to discuss with the builders design features that might be successfully adapted. Among the studios visited were Metro-Goldwyn-Mayer, Paramount, Universal-International, Warner Brothers, Walt Disney, California Studio and Republic.

Several types of wall construction were considered, including the conventional stud and stucco used for many older sound stages in the Hollywood-Los Angeles area, and interlocking concrete block construction. It was finally decided to use the "tilt-up" concrete walls, a type of construction used for many buildings on the West Coast. This type of building construction is fireproof, no more expensive than other types, and because of the mass and thickness of the concrete wall, it is comparatively resistant to low-frequency sounds. It was decided to make the walls 6 in. thick although other studios in the area have 4-in. walls.

The height of the walls made it necessary to lift them in two sections. On the first lift, the lower 20 ft of wall was raised into place in a single day, after the wall slabs had been poured and cured. Each slab was 18 ft wide, 20 ft high, 6 in. thick and weighed about 23 tons. About six weeks later when the second layer of slabs had been poured and cured, they were lifted into place and positioned on top of the first set of slabs.

In the "tilt-up" concrete wall method of construction, the first operation in the process is to pour most of the floor area in a single concrete slab and allow it to cure before the wall slabs are poured on top of the floor. To prevent the first wall slab from sticking to the floor, a special type of oil is poured over the floor before the concrete is poured into the forms. This oil prevents direct contact between the wall slab and the floor. Later on, when a crane is used to lift the walls, they do not stick to the floor. When a second, third or fourth wall slab is poured on top of the first one, each layer is coated with this same oil material to prevent sticking. Usually four or five layers of wall slab are poured on top of each other, one at a time, allowing a curing period to elapse between pourings.

After the lower and upper wall sections have been lifted into place, forms are built around the space between the wall sections. When these forms are completed, the supporting columns are poured from the top to tie the entire structure together and to support the walls. When the slabs are lifted into place, they are temporarily propped up with long tubular braces which are hooked to the wall slabs and drilled into the concrete floor with a special air hammer. These braces keep the walls in place until the column forms are ready and the concrete columns have been poured. Later, when the concrete columns have set, the tubular props or braces are removed. After the walls and columns are in place and sufficiently cured, the wood trusses are assembled on the job and lifted into place with a giant crane.

The roof is also of special soundproof, multilayer construction, alternating such materials as composition roofing; $\frac{3}{4}$-in. fiberboard, asphalt impregnated; a $\frac{5}{8}$-in. plaster board; and $\frac{1}{2}$-in. plywood. The final layer on the inside of the roof is a 2 in.-thick, long-fiber glass fiber. A special white asbestos roofing paint is applied to reflect the sun's rays and help keep the studio cool.

Ventilation

Two large 2-speed fans in the roof provided means of exhausting warm air which rises to the ceiling in any sound stage where lighting equipment is in use. Each of these fans exhausts air through a penthouse on the roof which has a labyrinth type of arrangement so that the air must pass around several baffles, all of which are lined with glass fiber. This arrangement absorbs airborne sounds which may be present. These two exhaust fans are controlled by a remote switch which can be placed anywhere in the studio. It is usually located at the mixer's console, so that he can start and stop the fans at any time without leaving his mixer console. Two speeds are provided so that at high speed air can be exhausted very

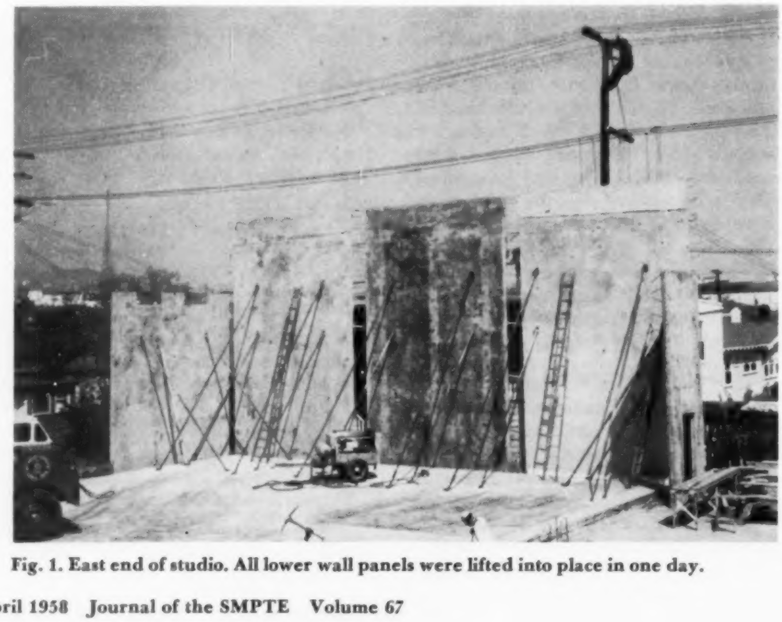


Fig. 1. East end of studio. All lower wall panels were lifted into place in one day.

Presented on May 3, 1957, at the Society's Convention at Washington, D.C., by John Flory for the author, James A. Larsen, Academy Films, 800 North Seward St., Hollywood 38. A 7-min, 16mm film supplemented the paper.
(This paper was received on November 8, 1957.)

Fig. 2. Poured and cured wall panels stacked one on top of the other ready to be lifted into place.

Fig. 3. Typical single panel with door and window opening cast into the panel. This single panel weighs about 23 tons.

quickly and at low speed the fans can be left running almost continuously during rehearsals and setup time. During a sound take, however, the fans cannot be used, even at low speed, because of the noise.

The fresh air intakes are located on the north wall which is the shady and coolest side of the building. The fresh air is brought into the building through ten openings in the north wall. These openings are 4 ft wide and $1\frac{1}{2}$ ft high and are located 20 ft above the floor level. On this wall, there is an 8-in. air space between the 6-in. concrete wall and the inner wall. These air intake ducts are lined with glass fiber on all four sides so that airborne noise is absorbed before it enters the studio at floor level. This means that the air must travel through a duct, 20 ft long and completely lined with glass fiber before it reaches the studio floor.

At the bottom of these air ducts and on the inside wall of the studio, doors or covers have been provided so that in the wintertime the air ducts can be closed completely, if desired, to prevent loss of heat from inside the studio. These covers can also be used if, for any reason, the stage must be closed up to exclude any noises that might get through the 20 ft of lined ducts. Experience in shooting three feature length films for theatrical release and the shooting of films for television has shown that it is not necessary to close these doors during a take.

It was decided to use a dead-air space only 4 in. thick in the other three walls as their space was not used for air circulation. The inner wall of the studio, which is the same on all four sides, is constructed of 2 by 4-in. studs which are merely a framework to hold the insulating materials. On one side of the 2 by 4's a $\frac{1}{2}$-in. soft fiberboard material is nailed. On the opposite side of the 2 by 4, a $\frac{5}{8}$-in. plasterboard is nailed. The seams or joints of these two materials are staggered so that they do not come opposite each other. Then on top of the $\frac{5}{8}$-in. plasterboard a 2-in. acoustic quilt of long-fiber glass fiber is installed in the conventional way. From the floor level, to 12 ft above the floor, this 2-in. glass fiber quilt is covered with $\frac{1}{4}$-in. hardware cloth, primarily to prevent damage to the soft glass fiber surfaces. Above the 12-ft level, up the remainder of the walls and across the entire ceiling area, the glass fiber is not covered with the hardware cloth. A special type of shockmount bracket was used in attaching the inner wall to the outer concrete wall so that vibrations would not be transmitted through the connecting members that hold the walls together.

Catwalks

The bottom of the roof trusses is $24\frac{1}{2}$ ft above the floor level, and a permanent catwalk structure is built on the top side of the trusses for the convenience of electricians, riggers and others who need to work from up above. Both a stairway and a ladder are provided to reach the catwalk area. Light-

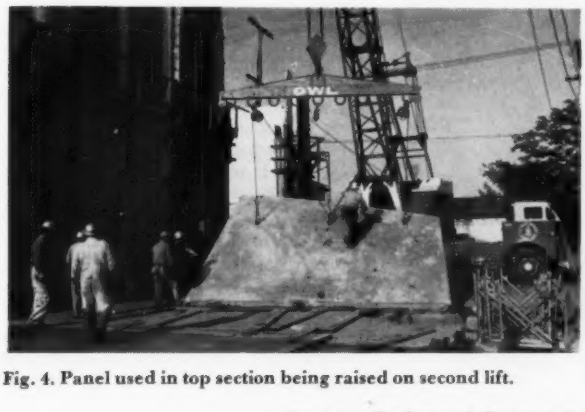


Fig. 4. Panel used in top section being raised on second lift.

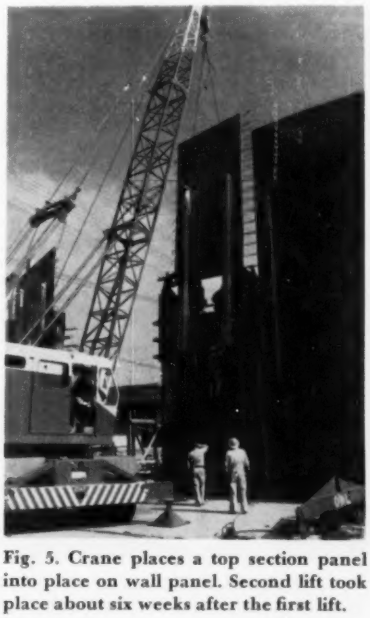


Fig. 5. Crane places a top section panel into place on wall panel. Second lift took place about six weeks after the first lift.

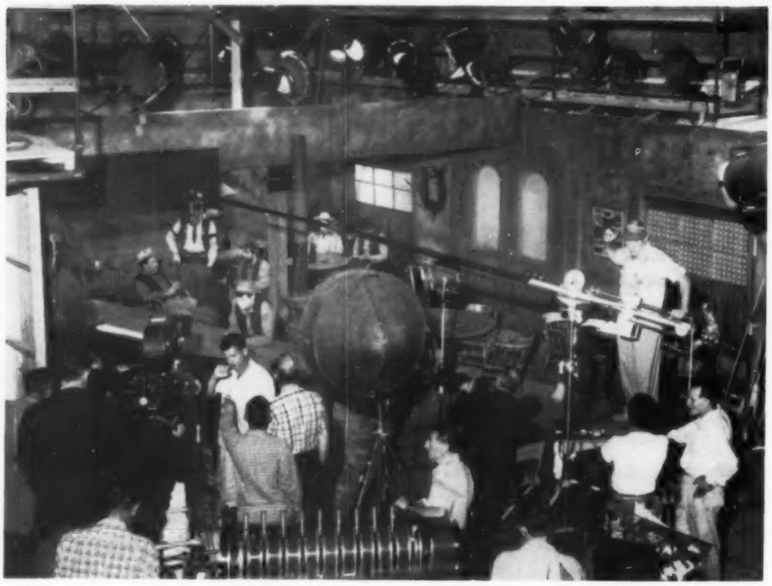


Fig. 6. Typical set built inside sound stage. This set was used in the film *Storm Rider* produced by Regal Films for 20th Century-Fox release.

ing equipment is suspended from chains and metal hangers from a network of beams at the same height as the bottom of the trusses. This network of beams is placed every 4 ft so that the temporary scaffolding used to support lighting equipment can be located almost anywhere in the studio. The "patented scaffolding," typical of many motion-picture studios in the Los Angeles area, is used in this studio. Metal hangers are used because of their durability and wooden beds covered with hardware cloth are used because of their nonconductivity of electricity. Some studios have used wooden hangers in similar situations. These are quite satisfactory but do not last as long as the metal hangers.

Lighting and Power

Two-thirds of the electric power in the studio may be obtained from two switch panels located in the catwalk area. This makes it possible to keep most of the cabling for the overhead lighting off the studio floor, which saves time and is convenient for the entire crew. The total amount of power available in the studio is 3600 amp at 120 v. One-third of this power is available from a single switch panel on the floor. This panel is used to power lighting units which must be located on the floor, such as fill lights, small spotlights, and other lights for general illumination on the set. Also, 220-v 3-phase power has been provided for operating recorder motors, camera motors, background projection equipment and any other special equipment. The standard "redlight" system is controlled remotely from the same switching mechanism which the mixer uses to control the blower fans. The signal redlights are located at both pedestrian entrances to the sound stage.

Special Features

A large rolling door, 18 ft wide and 20 ft high, has been provided at one end of the stage for bringing in large props, prefabricated set units and other large pieces of equipment. This door rolls on two large wheels about the size of freight car wheels. In the floor of the studio a track similar to a railroad track is cast and leveled very accurately so that the door rides evenly on the railroad track. One man can open the door easily using the geared pulley arrangement provided.

Extra attention was given to making the concrete floor as level as was humanly possible in the casting of a one-piece floor of this large size. A special type of insert was installed in the concrete floor, at 4-ft intervals in all directions, so that set braces and the bases of set units could easily be solidly bolted to the concrete floor. These special inserts are threaded and contain an Allen setscrew which is removed when the plug is in use. The concrete floor is so smooth that tracks are not required when using a camera dolly. Also, the concrete floor does not creak and groan like many of the older wooden stage floors.

Because the sound stage is so well insulated and because the winter weather in Southern California is comparatively mild, we found it quite practical to heat the entire sound stage with six thermostatically controlled electric "unit" heaters. Each heater has a capacity of 4,600 w and when the heaters are distributed around the studio, it can be heated from outside temperature to about 70 F in a few hours. Obviously, after shooting begins, the heat from the light units is sufficient to heat the studio so that the heaters are necessary only to take the chill off in the morning and during rehearsal or construction time when the studio lighting is not in use.

The house lights or "work lights" are operated by two switches, one at each pedestrian entrance to the studio. At first, we had these switches wired to a relay which was held closed by a coil requiring power on it to hold it closed. We found that the hum from this small coil was sufficiently loud to disturb the sound recording when the microphone was in the vicinity of the location of the relay. It was necessary to change this relay to a new special type which is mechanically held closed or open and is merely moved from one position to

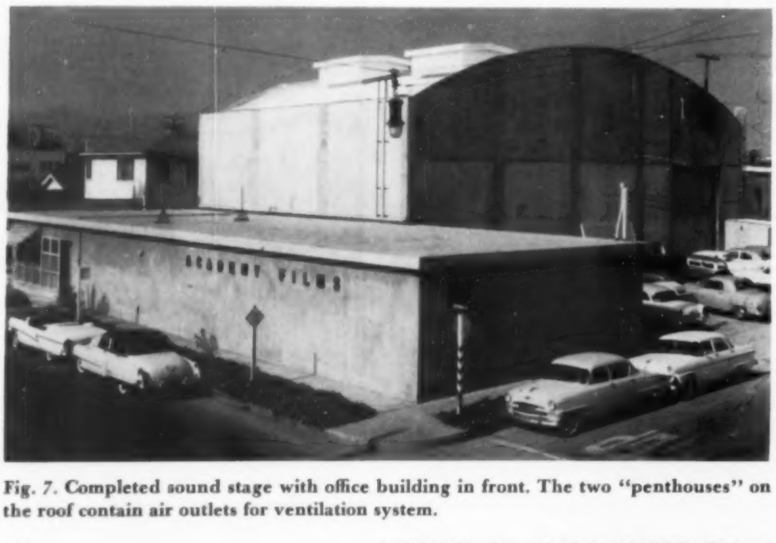


Fig. 7. Completed sound stage with office building in front. The two "penthouses" on the roof contain air outlets for ventilation system.

the other by power applied to a coil. In this arrangement, there is no power applied to the coil when the house lights are either on or off, but only when changing from one condition to the other. All other possible sources of noise within the studio are eliminated such as electrically refrigerated drinking fountains, telephones and plumbing in the studio proper.

The double plateglass "view ports" were provided in one of the studio walls which adjoins our sound-recording monitor room. If desired, the sound recorder can be put in the next building near one of the view ports. In this location, the recordists can look over the stage and watch for visual signals from the mixer or assistant director. Communication between recordist and mixer is accomplished by a public address system. Cables for this system and the sound-recording channel are fed through four large-diameter conduits which were cast into the concrete floor when it was laid. Two of these conduits are still vacant and available for future requirements.

Three 4-in. diameter conduits were placed under the wall adjoining the parking lot area so that the cables from a sound truck, parked outside the stage, could be brought through without making a sound leak in the insulated wall. Another 4-in. conduit has been provided to bring in cables from a d-c generator which can be parked in the same parking lot. All of these seemingly small details make the stage more practical and useful to an independent film producer.

Proposed American Standard

A Proposed American Standard, PH22.114, 16mm Azimuth Test Film, Magnetic Type, is published here for a three-month period of trial and comment.

This proposal was revised and resubmitted to the Sound Committee four times before it was permitted to proceed to the Standards Committee. Your attention is directed to some of the comments which were considered by the committee prior to this published version. It was suggested that the title be changed to "16mm Azimuth Alignment Test Film." Although the proposed test film would be most helpful as a tool for aligning magnetic heads, it can also be used for routine checking. Therefore it was decided to retain the original title.

There was some objection regarding the dimensioning of the magnetic soundtrack from the centerline rather than the edge of the film. Both forms of dimensioning appear in American Standards; however, the Sound Committee has adopted the practice of indicating track location by dimensioning the recording head using the centerline of each head because the manufacturing tolerances of head width have less effect on the track position.

The question of using a square wave in place of a sinusoidal wave was considered. It was the consensus of the committee that square waves are difficult to make with existing modulators and their use would increase the difficulty of making the test film.

A test film, M16AL, made in accordance with this Proposed American Standard may be purchased from the Society.

All comments should be addressed to Society Headquarters, attention of J. Howard Schumacher, Staff Engineer, prior to June 15, 1958. If no adverse comments are received, the proposal will then be submitted to ASA Sectional Committee PH22 for further processing as an American Standard.—*J.H.S.*

Proposed American Standard

16mm Azimuth Test Film, Magnetic Type

PH22.114

1. Scope

1.1 This standard specifies a test film with full-width magnetic coating having a magnetic sound record to be used for aligning the azimuth of magnetic heads on 16mm magnetic recording and reproducing equipment.

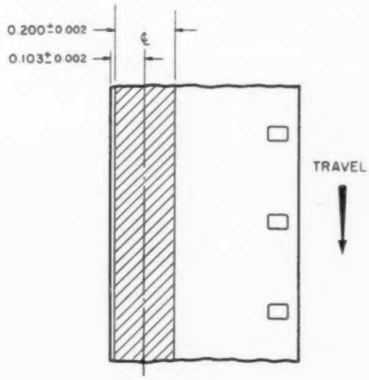
2. Test Film

2.1 The test film shall have an original sound record whose wave shape is approximately sinusoidal and whose frequency is about 7000 cps when the film rate is 24 perforations per second, approximately 36 feet per minute.

2.2 The sound record shall have correct azimuth within ± 3 minutes of arc.

2.3 The recording shall be made at 100 percent modulation level with a tolerance of + 0 — 2 db. 100 percent modulation is defined as the recording head current at which 3 percent total harmonic distortion occurs at a signal frequency of 1000 cps.

2.4 The locations and dimensions of the sound record shall be in accordance with American Standard 200-Mil Magnetic Sound Record on 16mm Film Base Perforated One Edge, PH22.97-1956, or the latest revision thereof approved by the American Standards Association, Inc., and as shown in the drawing.



3. Film Stock

3.1 The film stock used shall be of the low-shrinkage safety type, cut and perforated in accordance with American Standard Dimensions for 16mm Film, Perforated One Edge, PH22.12-1953, or the latest revision thereof approved by the American Standards Association, Inc.

4. Length of Film

4.1 The film shall be supplied in 100-ft lengths.

5. Identification

5.1 The film shall have identification markings at both ends.

APPENDIX

(This Appendix is not a part of Proposed American Standard 16mm Azimuth Test Film, Magnetic Type, PH22.114, but is included to facilitate its use.)

Fluctuations in signal level may seriously impair the ease and precision of setting an azimuth adjustment. It is recommended that the signal level when reproduced on high quality equipment and measured with a VU meter be held to a tolerance of ± 0.5 VU through any 100-ft length of film. Exception may be made for occasional rapid level fluctuations such as may be caused by "drop-outs."

NOTE: A test film in accordance with this standard is available from the Society of Motion Picture and Television Engineers.

NOT APPROVED

news and reports

High-Speed Photography Activities

Numerous activities have results that speak for themselves, but a general report will clarify parts of the field of operations and credit those responsible for various areas.

Missile Photography Symposium

Although the first part of this issue of the *Journal* is obviously an important result of great enthusiasm and effort given by Sidney M. Lipton, it should be recorded that he organized that symposium on very short notice and that within four weeks he had scheduled the substantial sessions. The published group discussion is only a partial reflection of the value to these specialists of their meeting as a part of the 81st SMPTE Convention. The publication of this group of papers has been possible only because the Society had special cooperation from many authors in differing situations.

These and other missile photography papers published in other issues of the *Journal* will later be grouped in Volume 7 of the Society's High-Speed Photography reprint series.

Sessions and Congresses

The SMPTE 82d Convention had two sessions on high-speed photography and instrumentation, organized by Topic Chairman Max Beard. The subject matter was highly diversified, including projection of much high-speed motion-picture footage. A consistently large audience appreciated the papers and demonstrations, including methods of reproducing sequence or framing camera material for motion-picture presentation which permitted good visual analysis of motion that is normally lost in sequence photography.

The SMPTE 83d Convention has a substantial roster of papers organized by Topic Chairman Bob Betty for April 22. These papers will soon begin to appear in the *Journal*. (See the March *Journal* for the Advance Program or see the Convention Program, available upon request.)

The Fourth International High-Speed Congress will be held September 22–27, 1958, at Cologne, as reported in the *Journal* for November 1957. The Congress is held during the week preceding Photokina, the annual photographic exposition held at Cologne. This year a special section at Photokina is reserved for equipment for high-speed photography. J. H. Waddell of Fairchild Camera & Instrument Corp. has accepted an invitation to attend as an American representative. Contributors and others planning to attend the Congress may also write to Dr. H. Schardin, Weil am Rhein, Rosenstrasse 10, W. Germany, who will supply a brochure.

The Fifth International Congress is scheduled to be held during the SMPTE Convention, in the Fall of 1960, Washington, D.C. A five-man committee has been appointed to arrange participation of other Societies with similar interests and to make preliminary plans for the Congress. Committee members are: Richard O. Painter, Morton Sultanoff, Harold E. Edgerton, Carlos H. Elmer and John H. Waddell. The U.S. State Department has presented a request to the High-Speed Photography Committee to act as co-sponsor of the Congress. Plans are underway for a papers program of approximately 75 papers and arrangements for an exhibit have been discussed. Suggestions for papers are welcome and may be addressed to any member of the five-man committee in charge of arrangements or to the Staff Engineer at Society Headquarters.

High-Speed Photography Vol. 6

This latest of the series of reprint volumes was published at the end of last year. The interest of recent years in missile research is reflected in the contents. Eight of the 27 articles deal directly with ballistics and military applications. Other articles cover timing devices, cameras, film, illumination, projectors, data analysis and applications. This volume is in the same format as the preceding volumes in the series, 6 by 9 in., paper cover. It contains 200 pp. The 27 papers are those collected for reprinting since Vol. 5 in 1954. It is priced at $4.50 with the customary discounts for members and large lots.

Only Vols. 4-6 are now available. Volumes 1–3 have long been out of print and are not obtainable from Society headquarters. It is sometimes possible to buy them through the "Journals Wanted" notices in the *Journal*.

The success of these volumes in the past decade is a tribute to the first Chairman of the Society's High-Speed Photography Committee, John Waddell, who instituted the program that produced Vols. 1 and 2 in 1949.

Committee Meetings

The SMPTE High-Speed Photography Committee met during the Fall Convention at Philadelphia. One of the subjects of discussion was the scope of the Committee's interests and the definition and limitation of its proper activities. The scope of the Committee as given each year recently in the list of SMPTE Engineering Committees (Part II of April *Journals*) is: *To make recommendations and prepare specifications for the construction, installation, operation, and servicing of equipment for photographing and projecting pictures taken at high repetition rate or with extremely short exposure times.* It was questioned whether this definition was comprehensive enough to include all the committee's activities, and the suggestion was made that the wording be extended to cite high-speed motion-picture photography, time-lapse, high-speed flash, instrumentation as applied to high-speed motion-picture photography, and time-lapse and research and development as applied to motion-picture photography. It was also suggested that the Committee's categories of interest might include reference to: (1) camera lenses and shutters, (2) exposure controls, (3) record processing equipment, (4) data reduction and (5) sensitized products.

There was consideration of overlapping interests, particularly with regard to SPSE and SPIE, cited below.

An SPSE/SMPTE Committee met on February 18 to explore and study possible areas of overlap in activity between the

"The Academy Awards" presented on March 26 were especially meaningful this year for the Society, even though the Academy television show time ran out just before Bette Davis presented an Oscar to Barton Kreuzer, SMPTE President, honoring SMPTE for

The Society's Forty-Two Years of Service to the Industry

Lorand Wargo, H. M. Little and H. L. Baumbach, authors in the February 1958 *Journal*, were represented in the television show by Mr. Wargo's appearance to receive an Oscar for

development of an automatic printer light selector

two organizations. For SPSE, E. K. Kaprelian and John A. Maurer attended and George T. Eaton was kept away by inclement weather, as were Axel G. Jensen and Richard O. Painter for SMPTE. Present for SMPTE were Glenn E. Matthews, E. M. Stifle and J. Howard Schumacher. The main area of possible difficulty seemed to be in the presentation and publication of technical papers relating to high-speed photography. It was agreed that it would be extremely difficult to draw a fine line separating the activities of the two Societies. It was noted during the discussion that the position of the SPSE on high-speed photography is that continuous film is an SMPTE activity and individual exposure photography is an activity of SPSE. It was agreed that while some overlap does exist between the Societies, there were no specific areas in conflict at the present time.

Immediately following is our brief résumé about the SPIE, and after that the SPSE story by its President.—*R.H.*

Society of Photographic Instrumentation Engineers

The Society of Photographic Instrumentation Engineers has announced plans for its 1958 Exhiborama and Second National Symposium. Scheduled to be held August 1–3, 1958, at Los Angeles, this Symposium will generally follow the procedures of the first Symposium held August 1–2, 1957, at the Ambassador Hotel, Los Angeles. Theme of the 1957 Symposium was "Photo Instrumentation — Metric Miracle." The SPIE was organized to "foster the exchange of information and knowledge of the Science of Photo-Optical Measurements and to serve industry as a clearing house for data on all phases of its application."

The SPIE has announced the policy of recording all sessions, with duplicate tapes (at $3\frac{3}{4}$ ips) available at cost to SPIE members if ordered, in writing, during the Symposium.

Officers are: *President*, Charles E. Taylor; *Vice-President*, Robert M. Betty; *Treasurer*, Robert Woltz; *Secretary*, Stanley E. Baker.

Society of Photographic Scientists and Engineers

The Society of Photographic Scientists and Engineers was formed in December 1956 and is comprised of members of the former Society of Photographic Engineers and some members of the former Technical Division of the Photographic Society of America. The action was taken because of the similar and, in many areas, identical interests of the two groups. The new organization has a membership of about 1200.

Membership is made up of persons who are engaged professionally in one of the many technical activities directed to the study of photographic processes or to the production, improvement and adaptation of photographic goods to the needs of man.

The Society considers as its area of responsibility the general field of scientific and applied photography but leaves the subject matter of the specialized fields of application, such as motion pictures, photogrammetry, and others, to the organizations now serving them. The Society is concerned primarily with both the science and application of the photographic process.

Major activities of the Society are its Annual Technical Conferences at which papers are presented and discussed, its engineering committee operations and the publication of its journal, *Photographic Science and Engineering*. The Society holds a charter issued under the authority of the District of Columbia agency for corporate bodies and operates under a Constitution and Bylaws consonant with it, with a purpose which includes publication, cooperation with other organizations through research, by teaching and by study, and furthering the application of science to photography and photography to science, engineering and industry.

The Society's Officers are:

President, George T. Eaton, Kodak Research Laboratories, Rochester, N. Y.

Executive Vice-President, Steven Levinos, Ansco, Binghamton, N.Y.

Engineering Vice-President, John A. Maurer, JM Developments, Inc., New York, N.Y.

Editorial Vice-President, Peter Krause, Ansco, New York, N.Y.
Financial Vice-President, Herbert Meyer, Motion Picture Research Council, Hollywood, Calif.
Secretary-Treasurer, Norton Goodwin, Lawyer, Washington, D.C.
Managing Secretary, Edward S. Cobb, U.S. Naval Photographic Center, Washington, D.C.

There are now Chapters at:

Binghamton, N.Y.	Rochester, N.Y.
Boston, Mass.	Southern California
Cleveland, Ohio	Southern Lake, Michigan
Ithaca, N.Y.	
Monmouth, N.J.	Washington, D.C.
New York, N.Y.	Mid-Gulf Area

Information about membership in the Society and the local chapters is available from the Managing Secretary, Edward S. Cobb, Box 1609, Main Post Office, Washington, D.C.

Photographic Science and Engineering is the official publication of the Society, four numbers to a volume. The first two numbers of Volume 1 were issued in 1957; Nos. 3 and 4 of Vol. 1 and Nos. 1–4 of Vol. 2 are planned for 1958. Subscription to nonmembers is $8.00 a year; single copies, $2.00 each. These are available from the Managing Secretary at the address above.

Photographic Engineering, which ran for seven volumes, is still available as back issues obtainable from the SPSE Managing Secretary. Volumes 1 through 5 cost $5.00 a volume; Vols. 6 and 7, $8.00 each.

The SPSE 1957 Annual Technical Conference held at Asbury Park, N.J., September 9–13, was a very substantial program of 44 papers assembled by Charles E. Ives and Karl D. Leistner. Five of these papers were published in Vol. 1, No. 2, and several more appear in the Society's *PS&E* No. 3.

The 1958 Conference will be at the Manger Hotel, Rochester, N.Y., October 6–10. Conference Co-ordinator is Ira R. Kohlman, c/o Technicolor New York Corp., 533 West 57 St., New York 19. An extensive papers program, including a special group of papers related to the IGY, is being organized by Papers Program Chairman Jerome S. Goldhammer, c/o CBS Research Laboratories, 485 Madison Ave., New York 22. An exhibit of special photographic equipment is being organized by Exhibit Chairman Richard van Steenburgh, c/o Fairchild Camera & Instrument Co., Robins La., Syosset, L.I., N.Y.

After little more than a year of operation, the SPSE has held a very successful technical conference, has its publishing program underway, and has substantial activity among its chapters. The Society also cooperates with the American Standards Association and has assumed the responsibility for an amateur photo-track program in cooperation with the Smithsonian Astrophysical Laboratories.—*George T. Eaton*, President, SPSE, c/o Eastman Kodak Co., Bldg. 59, Kodak Park, Rochester 4, N.Y.

Association of Cinema Laboratories

The Association's Annual Meeting was held at the Warwick Hotel in New York on February 19. Officers and a Board of Directors were elected for 1958. Eight technical definitions of film terminology submitted by the Nomenclature Committee, headed by Neal Keehn of Kansas City, were adopted. Thirty-three members and guests attended the all-day session and cocktail-luncheon which comprised the annual business meeting of the group. In the afternoon presentation of technical advancements in the industry was made by film manufacturers and equipment firms.

The new officers and Board of Directors of the 57-member group are: Reid H. Ray of St. Paul, re-elected President; Leon Shelly of Toronto, re-elected Vice-President; George Colburn, Chicago, Secretary; Kern Moyse, New York, Treasurer; with Board Members, Don M. Alexander, Colorado Springs; Spencer W. Caldwell, Toronto; Louis Feldman, New York; Byron Roudabush, Washington; and Sidney Solow, Hollywood. Directors holding over for another year are G. Carleton Hunt of Hollywood and George Colburn, Chicago.

The Association announced the completion of a service booklet prepared by a committee on "Laboratory Practices on Films for Television" for free distribution to all concerned with television film production. It is available from the Association's headquarters, 1905 Fairview Avenue, N.E., Washington, D.C.

Another project the ACL group has under preparation is a world-wide directory of film laboratories for informational purposes. The Committee announced that a list of 389 laboratories has been compiled

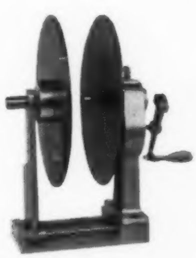
QUALITY

ECONOMY

DEPENDABILITY

H F C

HOLLYWOOD FILM COMPANY
precision film editing equipment



NEGATIVE REWIND

The unit is designed as a fool proof method to tightly wind original material without the danger of tearing or scratching the film. The rolling action of the cover flange self-aligns the film constantly.

$125.00 EACH
NRU-1 (1000′ flanges)
NRU-1L (2000′ flanges)

EASY EDITOR

Reels driven by friction, this permits the operator to quickly remove reels and insert others.

Braking levers prevent film pileup.

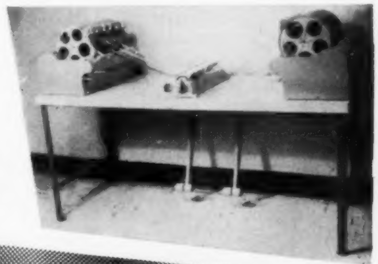
Six 1000′ 35mm reels can be rewound at the same time.

Motor rewinds wind film in either direction.

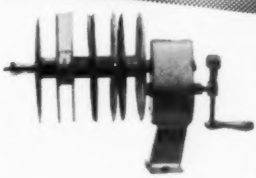
Micro switches cut off power after last reel has run out.

Available with foot controls.

PER SET..........$920.00
WITH FOOT CONTROLS $975.00

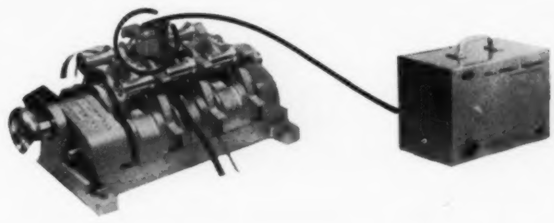


DIFFERENTIAL REWIND WITH GIMMICK



Four (4) uneven reels of film can be wound up evenly on a single shaft. 16 or 35mm film or a combination of both may be rewound. Each reel is handled individually on the four (4) reel shaft and even takeup of all reels is assured. Two (2) reels are driven by the differential action of the rewind and the others with the differential gimmick.

$135.00



POWER REWIND

Designed to wind 16 and 35mm film on reels up to and including 3000′ rolls.

A heavy duty 1/10 HP variable speed motor controlled by a carbon pyle foot rheostat, permits the operator to vary the speed during the winding operation. A side lever shifts the motor to either neutral or engaged position. Neutral position is used when the film is being wound back on the hand rewind. It permits the reel to free wheel without fighting the thrust of the motor. Film can be wound on cores with the aid of the HFC tightwind TWC-1 (16-35) combination.

$124.50
TIGHTWIND COMBINATION (16-35) $35.00

FILM SYNCHRONIZER

HFC film synchronizers enable the film editor to accurately match the picture and sound track.

All types of synchronizers of 16 or 35mm are available from stock, as well as 16 & 35mm combinations; and 35 - 32 and 35mm combinations. Units to handle 55mm, 65mm and 70mm are available on special order.

MAGNETIC TAPE SYNCHRONIZER ATTACHMENT

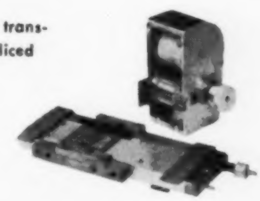
This attachment permits the user to sync dailies quickly without using the editing machine.

It can use the amplifier in the editing machine or sound reader, or the HFC tape reader amplifier especially made for this use.

AUTOMATIC FILM SPLICER

The HFC Automatic Film Splicer uses a special transparent tape, perforated to match the film to be spliced and coated on one side with pressure adhesive. The tape is rolled onto the film automatically from a precision sprocket. Registration pins assure perfect lineup of film. 16 and 35mm models are available.

$185.00 EACH



HOLLYWOOD FILM COMPANY

956 N. SEWARD ST.
HOLLYWOOD 38, CALIFORNIA
HOllywood 2-3284

WRITE FOR FREE CATALOGUE

BRANCH OFFICE
524 W. 43RD ST.
NEW YORK, NEW YORK
LOngacre 3-1546

and it hopes to have the complete directory ready for release by June of this year.

Six new members were announced at the meeting, bringing the membership to 57, including members in Canada and the U.S.

The next meeting of ACL will be in Hollywood, April 21, at the time of the Spring Convention of SMPTE.—*Reid H. Ray*, ACL President.

Education, Industry News

Photokina 1958 will be held at Cologne, Germany, Sept. 27 through Oct. 5. This will be the sixth of these international photographic and cinematographic exhibitions. Exhibitors from approximately 75 countries, including the United States, are scheduled to show recent products and developments. Transportation arrangements and hotel reservations are being handled by Karl Hardach Travel Service, 11 W. 42 St., New York 36.

Charles Ginsburg, recipient of SMPTE's David Sarnoff Award at the Society's Fall Convention at Philadelphia, has been given a new honor, the Vladimir K. Zworykin television prize. It was presented to Mr. Ginsburg at the Spring Convention of the Institute of Radio Engineers, held in New York, March 24–27. Presentation was made by Donald G. Fink, IRE President. The prize was first given in 1952. It goes to the Institute member who makes the most important technical contribution to electronic television during the preceding three years. Mr. Ginsburg was given the award for "pioneering contribution to the development of video magnetic recording."

The People-to-People Program was launched by the President at a White House Conference in September 1956. It is designed to promote world-wide contacts and activities among individuals which will further international understanding and friendship. Private in character, the program is distinct from official government activity. Approximately 1000 members have been appointed to 41 committees which will devise methods of making individual contacts through every possible avenue of communication. Each committee is autonomous and voluntary and is expected to initiate its own program in its particular field.

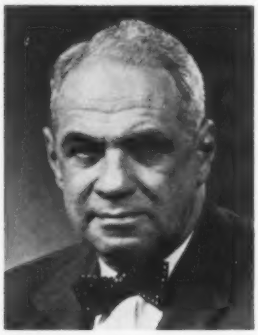
The list of committee chairmen contains many distinguished members, such as William Faulkner, Chairman of the Writers Committee; Eugene Ormandy, Music; Al Capp, Cartoonists; and others selected for outstanding ability and a purposeful approach to the aims of the program. The fields of motion-picture and television are given considerable emphasis as being among the most important mediums of cultural exchange. Y. Frank Freeman is Chairman of the Motion-Picture Committee. Frank Stanton and Harold E. Fellows are co-chairmen of the Radio and Television Committee. Mr. Stanton also serves on the Board of Directors of the People-to-People Foundation which was established in February 1957 to finance the program. Committee chairmen also serve as trustees of the Foundation.

The Program was described before the SMPTE at its Philadelphia Convention during the opening of the Session on International Television. George V. Denny, Jr., spoke for the People-to-People Foundation, Inc., which is located at 45 W. 45 St., New York 36.

Subliminal perception, only a few short months ago the subject of heated controversy (*Journal*, Dec. 1957, p. 778), appears to be finding its way to oblivion. The coup de grace has apparently been administered by NAB's TV Code Review Board which recently voted to ban this form of advertising. An amendment to the rules which will be submitted to the NAB TV Board May 1 at the Association's Convention at Los Angeles states: "The use of the TV medium to transmit information of any kind by the use of the process called "subliminal perception," or by the use of any similar technique whereby an attempt is made to convey information to the viewer by transmitting messages below the threshold of normal awareness, is not permitted." Earlier, the New York State Senate passed a bill making this form of advertising illegal within the State.


The "Enemy"
...Can We Stop Him?
a Traid 500 camera
will let us know!
There's the enemy — portrayed by Ryan's slippery, jet-fast Q-2 drone. Right now our missile is streaking for the intercept — will it make the kill? Traid's new 16mm "500," nestled inside the drone, will give us the whole story. Even at the icy altitude of 50,000 feet, this rugged little camera hums along at 200 frames per second to give us a target's-eye view of *exactly* how the missile did — or didn't. Thanks to this new Ryan-Traid combination, we're learning how to make our missiles more deadly — and how to sharpen the skills of our pilots and launching crews. We're also getting better reports on missile progress at less cost... one of the reasons that nearly *all* camera-equipped Air Force and Navy drones use Traid cameras.
Write for complete brochure on Traid products and development-manufacturing capabilities.
Traid 500—see it with the Ryan Q-2 drone at the 83rd SMPTE convention, April 21-25
Traid Corporation
17136 Ventura Blvd., Encino, California
High-performance instrumentation cameras and accessories for all purposes

Obituaries



Paul D. Hance, Jr.

Paul D. Hance, Jr., 56, President of Paul Hance Productions, Inc., died December 20, 1957, at City Hospital, Binghamton, N. Y., as the result of injuries incurred in an auto accident December 11.

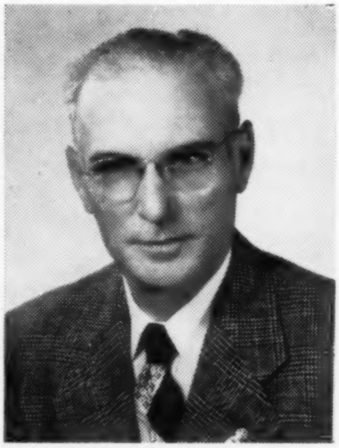
Prior to the organization in 1939 of his own production company, he had been associated with Newsreel Theatres, Inc., being there especially interested in the possibilities of changing over from 35mm to 16mm.

He was graduated from the University of Illinois in 1925 as an electrical engineer. He began his film career with the Bell Telephone Laboratories in New York, doing research in sound. He was a circuit design engineer and about this time was demonstrating the remote control of an auto through the streets of New York. In 1929 he went to Australia for three years to set up the sound film department of Fox-Movietone News.

From 1932 to 1935 he was associated with Soundmasters, Inc. and with the De Vry Company, working on a variety of technical applications of 16mm film, an interest which brought him to International Business Machines Corp. to organize an experimental 16mm motion-picture department.

His contributions to the 16mm film industry were great. He assisted in the building of one of the first Kodachrome printers in the United States. About twenty years ago in cooperation with Eastman Kodak chemists and Precision Film Laboratories personnel he developed and organized a practical system of making optical effects on Kodachrome prints through the use of chemical dyes. He also helped in the early development of the "A and B roll" system of printing.

A member of this Society, his most recent work was in the field of films for business and industry. A motion picture, *Glass and You*, produced for the Corning Glass Works, earned the Film Council of America's Golden Reel Award for 1955. His production of commercial and military subcontract films was carried out in recent years by about a score of associates in the company which he had built and which continues in production, with headquarters at 1776 Broadway, New York City.



Hervey T. Gardenhire

Hervey Thomas Gardenhire, 52, died December 30, 1957, in Veterans Hospital, McKinney, Tex., of rheumatic heart disease.

The Society of Motion Picture and Television Engineers, and the Dallas-Ft. Worth Section in particular, lost one of its staunchest and most dedicated friends in the death of Hervey Gardenhire.

Until the last months of his illness he never missed a Dallas-Ft. Worth Section or Board of Managers meeting unless it was absolutely impossible for him to attend. He drove alone from his home in O'Donnell

in far west Texas, over 600 miles round trip, in all kinds of weather, to meetings in Dallas or Ft. Worth when less brave souls would not venture across town.

Mr. Gardenhire was manager of several theaters for the Caldwell Theatres motion-picture circuit in Jal, Eunice and Hobbs, N.M.; and O'Donnell, Tex., for nearly 24 years.

Born on a farm in Tarrant County near Ft. Worth, in 1905, he showed mechanical ability at an early age and always had an excellent home workshop. Although not a graduate engineer he was a perfectionist with an inventive genius and natural engineering ability attested to in the many innovations installed by him in the projection booths of the theaters he served.

During his years in O'Donnell, Mr. Gardenhire was also very active in many civic and community affairs, having served as chairman of United Fund, Red Cross and Polio Fund drives, among others.

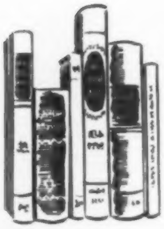
Hervey Gardenhire represented the kind of member the Society can least afford to lose and the hardest to replace.—*M. C. Hartung.*

James B. Hudders

James B. Hudders, 31, graduate in Electrical Engineering of Cornell University (1948), died after a short illness in Flower Fifth Avenue Hospital in New York on February 3, 1958. Mr. Hudders, since his graduation, had been a member of the Research and Development Division of Twentieth Century-Fox Film Corp., and since 1952 had been Director of the Television Research Laboratory for that company. Under his direction, the Eidophor large-screen theater television project reached commercial practicability. He was a member of this Society.

Jesse L. Lasky

The motion-picture industry lost one of its most colorful personalities with the death of Jesse L. Lasky on January 13. The 77-year-old producer died suddenly as he concluded a talk on his autobiography *I Blow My Own Horn.* The title is a reference to his early days as a traveling musician and vaudeville performer. Described as a "reluctant pioneer," chance brought him to the motion-picture field as it did so many other early titans of the industry. His early ambitions centered around vaudeville and light opera. A well-authenticated anecdote has it that his sole reason for becoming a motion-picture producer was to keep his friend Cecil B. DeMille from joining the Mexican Revolution which was in progress shortly before his first picture, *The Squaw Man,* was filmed. In the tradition of pioneers, Lasky made and lost several fortunes. At the time of his death he was completing plans for a Paramount production, *Big Brass Band.* He will probably be best remembered for the artistic excellence of many of his pictures and for his ability to recognize and develop dramatic talent.



books reviewed

Techniques of Magnetic Recording

By Joel Tall. Published (1958) by the Macmillan Co., 60 Fifth Ave., New York 11. i-xxii + 472 pp. illus. 5¼ by 8¼ in. Price $7.95.

This book fills a gap in our literature, since it emphasizes the operational rather than the technical side of magnetic recording.

Joel Tall teaches us many "tricks of the trade" which he has used in operating tape recorders for major networks in the broadcast industry since the earliest days of taped programming in this country. Of special interest are chapters on editing and re-recording, in which he discusses psychological and psycho-acoustic factors that must be taken into account when cutting and splicing a program. Certain "mistakes" that would be disregarded by a beginner can be quite jarring and disconcerting when heard in an edited program. On the other hand, a good editor can correct mannerisms, stammered syllables, etc., to make a smoother, more pleasant program than the original. With the advent of tape editing, artists at recording sessions are more relaxed than formerly. If a mistake is made, they start over at the last phrase, knowing that the editor will remove the "flufls."

Motion-picture and television techniques are covered in a chapter dealing with synchronous film techniques, double-system and single-system editing, synchronized tape-film systems, 16mm and 8mm film for amateur use, etc. Typical machines and editing procedures are described in detail.

There is an excellent chapter by Professor Peter P. Kellogg on Recording Sound in Nature. Anyone associated with recording in the field or using portable equipment and power supplies will profit through Dr. Kellogg's experience. Another subject treated in this book is legal use of tape recording and Mr. Tall's experience with the possibility of falsified records introduced as legal evidence.

Additional topics of operational interest are Maintenance, Spurious Printing, Radio Broadcasting Practice, Information Recording; Medical, Educational, Home, Telephone, Advertising, and Communication Recording. A limited amount of historical and theoretical material is presented to give a beginner some working knowledge of magnetic recording.

Most users of magnetic recording outside of the research laboratory who are interested in techniques for making good recordings, editing them, and keeping the equipment in excellent operating condition, will profit by the material in this book.—*Marvin Camras*, Physics Research Dept., Armour Research Foundation of Illinois Institute of Technology, 3440 South State St., Chicago.

Underwater Photography Simplified, 2d ed.

By Jerry Greenberg. Published (1958). Seahawk Products. P.O. Box 1157, Coral Gables, Fla. 46 pp. illus. 5½ by 8½ in Paper cover. Price $2.00.

This pamphlet is one of many which have recently appeared on the general subject of underwater photography. It is illustrated with black-and-white photographs. Although not outstanding in photographic excellence, they do illustrate points made by the author very nicely. The booklet seems to combine the fundamentals of black-and-white photography with the fundamentals of safe underwater procedure. An interesting group of illustrations of many of the available underwater still cameras as well as accessory electronic flashes, exposure meters, etc., is included.

The booklet contains a short chapter on the use of color film with available underwater light. It is obvious, particularly from this chapter, that Mr. Greenberg is a most ardent underwater fisherman, but his explanations of the behavior of specific color films and comparisons of various color products leave something to be desired. As is often the case with such publications, there is incomplete knowledge on the part of the writer and so personal opinions are passed along as gospel. This is not intended to be a major criticism of this particular work.

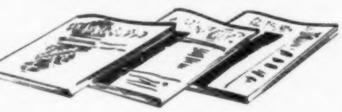
Aside from minor technical inaccuracies, the booklet can probably serve as a very

good guide to the underwater hobbyist if he wishes to add photography to his activities. Since the author sells underwater camera housings through his own firm, it is natural that the booklet is well illustrated with examples of this equipment. He is, however, careful to state the case well for all underwate- camera housings. *Norwood L. Simmons*, c/o Eastman Kodak Co., 6706 Santa Monica Blvd., Hollywood 38.

Test Equipment Annual for 1958, published by Howard W. Sams & Co., Indianapolis 5, Ind., contains product listings, including specifications, of over 350 pieces of equipment. The 116-page, 8½ by 11-in., paper-bound volume contains articles and listings under subject headings: General Use of Test Equipment; Test Equipment for Alignment; Test Equipment for Trouble Shooting; Test Equipment for Color TV; Special Application Test Equipment; Test Equipment Maintenance. It is available from the publisher at a price of $1.00.

Photography in Your Future by A. L. TerLouw, Educational Consultant for Eastman Kodak Co., is a six-page booklet especially valuable to counselors who may be called upon for advice about careers in photography. Applications of photography to science, engineering, industry and commerce are discussed in detail. The booklet is available without charge from Sales Service Div., Eastman Kodak Co., Rochester 4, N.Y.

current literature



The Editors present for convenient reference a list of articles dealing with subjects cognate to motion-picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer vol. 39, Feb. 1958

Shooting a Film for the Fair (p. 92) *R. Fernstrom*

The Cinemiracle Camera and its Development (p. 100) *P. S. Smith*

What You Can Do with Variable Camera Speeds (p. 108) *J. V. Mascelli*

Audio vol. 42, Jan. 1958

Amateur Sound Film Equipment (p. 24), *H. Thiele*

vol. 42, Feb. 1958

Amplifier Performance: Specifications and Evaluation (p. 24) *H. Burstein*

Simple Electronic Switch for Magnetic Sound System (p. 26) *P. Cremaschi*

Feedback and Distortion (p. 30) *G. F. Cooper*

Bell Laboratories Record vol. 36, Feb. 1958

An Experimental Signature-Verification System (p. 41) *F. K. Becker and J. R. Hefele*

British Kinematography vol. 32, Jan. 1958

The New "Eastman Colour Intermediate Film (p. 3) *A. F. C. Hirst*

An Improved Form of Pseudo-Stereophonic Recording (p. 17) *L. F. Rider*

Electronics vol. 31, Mar. 14, 1958

Etched I-F Amplifier Pares Color TV Cost (p. 135) *L. Ruth*

Hi-Fi Tape Recording vol. 5, Feb. 1958

The History of Magnetic Recording (p. 21) *M. Mooney*

First Use of Magnetic Sound on Film (p. 38) *L. A. Lembach*

International Photographer vol. 30, Feb. 1958

Video Tape Has Come to Stay (p. 5) *L. Schulman*

International Projectionist vol. 33, Jan. 1958

Preliminary Equipment Inspection (p. 5) *R. A. Mitchell*

vol. 33, Feb. 1958

Inspecting and Repairing Prints (p. 5) *R. A. Mitchell*

Strong's New "Blown-Arc" (p. 17)

Journal of the Audio Engineering Society vol. 6, Jan. 1958

Transistorized Magnetic and Photoelectric Input Circuits for Motion Picture Projectors (p. 4) *S. F. Bushman*

Variable-Speed Scanning of Recorded Magnetic Tapes (p. 26) *W. S. Latham*

Journal of the Franklin Institute vol. 265, Jan. 1958

Experiments in Television Over Telephone Cable Facilities (p. 1) *C. R. Kraus*

Kino-Technik vol. 11, Sept. 1957

Die Aufgaben des Labors in der Farbkopieranstalt (p. 306) *Dr. Würstlin*

Technisch-wirtschaftliche Probleme beim Farbkopieren (p. 309) *W. Behrendt*

Die Steigerung der Empfindlichkeit bei Farbfilmen (p. 316) *Dr. Kuhn*

Die Messung des Aufnahmelichtes bei Farbfilmen (p. 321) *H. Setzekorn*

vol. 11, Oct. 1957

Stätten Erlebter Wirklichkeit (p. 336) *Kl Milte*

USA Modernste Technik mit Luxus und Prunk (p. 342)

Frankreich Land alter Kultur und Film-Tradition (p. 346) *E. Schall*

Das Neue Filmtheater (pp. I–VIII)

Kaltlichtprojektion mit der Xenon-Maschine FH99X (p. 351)

Normalfilm-Projektoren Europäischer Produktion (p. 352)

Filmschonung durch Kaltlichtspiegel im Projektor (p. 354) *G. Haufler*

vol. 11, Nov. 1957

Hollywoods Aufstieg zum Filmmittelpunkt der Welt (p. 372)

Verdrängt das Fernsehen den Film aus Hollywood (p. 378) *L. Fürst*

Der Motion Picture Research Council in Hollywood (p. 385) *W. Beyer*

Walt-Disney-Studios: Phantasie und Präzisionsmaschine (p. 390)

vol. 11, Dec. 1957

Das Bauer-System zur Herstellung von 8-mm-Tonfilmen (p. 404)

Umfangreiches 8-mm-Programm der Niezoldi & Krämer GmbH (p. 406)

Bolex H 8, ein 8-mm-System für höchste Ansprüche (p. 410)

Zeiss Ikon-System für Aufnahme—Wiedergabe—Vertonung (p. 413)

vol. 12, Jan. 1958

Aufbau und Wirkungsweise einzelner Scheinwerfertypen (p. 4) *H. D. Lehmann*

Lichtströme von Kohlebogenlampen und ihre Messung (p. 10)

Proposed German Standards Suppl. I–IV

DIN 15,506 Blatt 2	Film 35 mm Prüf-und Messfilme Tonspalt-Test-film
DIN 15,822	Doppel-8-Tageslicht-Aufnahmespule
DIN 15,531	Rohfilmkerne

Leistungssteigerungen der Xenonlampe (p. 15) *Ulffers*

Anwendung Logarithmischer Masse in der Lichttecnik (p. 18) *H. Setzekorn*

Lichtstarke Schmalfilmlampen für Direkte Netzspeisung (p. 21) *P. Pfeiffer*

Automatik im Vorführraum Wandelt die Projektionstechnik (p. 24)

vol. 12, Feb. 1958

Der Breitfilm gibt dem Kino Neue Möglichkeiten (p. 30) *H. Jensen*

Das Kino Schafft die Verbindung zur Welt (p. 33) *J. W. Strobl*

Dem Technischen Fortschritt Aufgeschlossen (p. 34) *C. C. Schulte*

Noch immer Filmfreudigstes Land der Welt (p. 36) *E. Hoppe*

Wanderkinos Beherrschen Filmtheaterwesen (p. 38) *T. Lund*

Neubauten mit Freilicht Kombiniert (p. 40)

Eigenschaften und Anwendung Verschiedener Gleichrichter (p. 41) *H. Michel*

Die Neuen Prüf- und Messfilme für die Kinotechnik (p. 44) *A. Laufmann*

Die Regelung der Lautstärke bei Tonfilmverstärkern (p. 46) *G. E. Wegner*

Verspiegelte Lampen für die Schmalfilm—Projektion (p. 47) *M. Biermann*

Philips Technical Review vol. 19, No. 5, 1957/58

A Luminous Frame around the Television Screen (p. 156) *J. J. Balder*

Popular Photography vol. 42, Feb. 1958

Will Tape Replace Film? (p. 76) *John Durniak*

Tekhnika Kino I Televideniya, USSR (Cine and Television Practice) Jan. 1958

The Further Development of Cinematography (p. 1)

Immediate Tasks in the Development of Television (p. 10)

Scientific-Technical Section

Perspectives in the Development of Lighting Technology for Cinematography (p. 12) *V. G. Pell*

A Video Frequency Amplifier with Anode Inductance and Correcting Capacity in the Cathode Circuit (p. 19) *O. B. Lur'e* and *A. D. Sirgo*

Methods of Obtaining Three Color Signals from a Single Cathode Ray Tube (p. 31) *I. K. Malakhov* and *G. A. Morozov*

The Field of a Plane Magnetic Track Carrier (p. 40) *V. A. Geranin*

New Condenser Microphones (p. 45) *F. V. Semyakin*

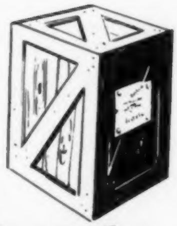
Condenser Microphone KM-57 (p. 58) *G. V. Butakov*

Filming Without Decor: A Survey of the "Travelling Matte" Method of Combination Filming (p. 61) *G. D. Aizenberg* and *B. F. Pluzhnikov*

The Experimental Construction of Auto-Collimators for Setting Out and Testing Distance Scales of Cinematograph Objectives (p. 65) *O. I. Resnikov*

Foreign Technology

Some Points in the Development of Modern Cine Technique (p. 69) *G. L. Irekil*



new products
(and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

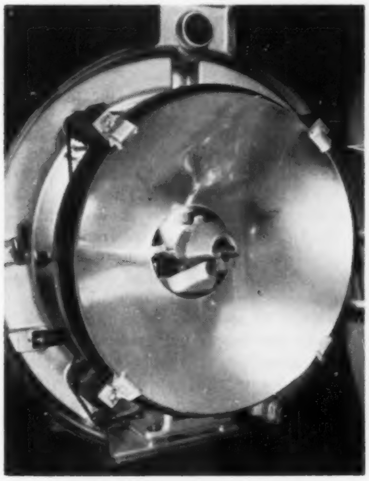
The Strong Jetarc Projection Lamp recently announced by Strong Electric Corp., 31 City Park Ave., Toledo 1, Ohio, is a reflector type projection lamp employing the "blown arc" invented by Dr. Edgar Gretener, Zurich, Switzerland (*Journal*, Oct. 1950, pp. 391–413). The "blown arc" was so named because the form of the arc is changed by air pressure from jets arranged in concentric circles around the positive carbon so that they stroke the burning end of the electrode. The air pressure is supplied by a blower which is an integral part of the lamp.

In the process of reshaping, the arc stream is constricted and thus greatly increases the brilliance of the light source. Because of the cylindrical shape of the arc, the light pickup angle can be increased to more than 260°. In the new lamps, an auxiliary 6-in. spherical mirror is positioned behind the positive carbon to supplement the usual 160° pickup angle. When projecting small aperture 35mm pictures, the lamp is reported to deliver 46,000 lm; for CinemaScope 35mm, 55,000 lm; for MGM 65mm and Todd-AO 70mm, 56,000 lm; and for Fox CinemaScope 55mm, 65,000 lm. Distribution of light over the entire screen area can be operated from a minimum of 80% up to 100%.

A 10mm by 27-in. nonrotating Ultrex positive, which passes through the center opening in the auxiliary mirror, is burned with a rotating $\frac{7}{16}$ by 12-in. solid graphite negative carbon at 140 to 160 amp and 70 to 78 v. Also, 10mm by 25-in. Hitex positives may be burned at 125 to 140 amp

or 10mm regular positives at 110 to 125 amp.

The lamp employs a 21-in. glass cold mirror with a 6½-in. focal length and 42-in. working distance. It has been made an integral part of the rear door and need not be exchanged for the projection of film of any width. The position of the burner is not changed since all focusing is done by shifting the main reflector. The lamp, which is 45 in. long by 29 in. wide by 43 in. high, is reported to be cool in operation, with heat at the aperture no greater than when burning an 8mm copper-coated trim at 70 amp without a heat filter. Water cooling is used for the auxiliary reflector and the positive and negative carbon heads. The cooling agents must be operating before the lamp can be energized.

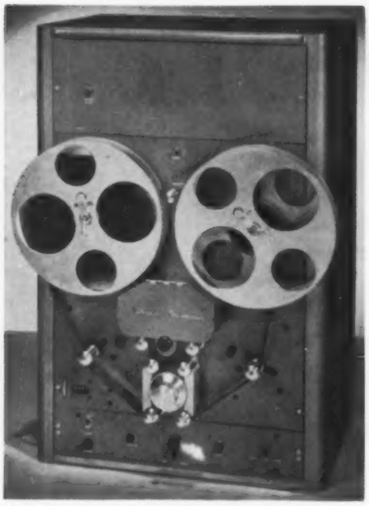


A 220-v, 3-phase selenium rectifier, designed as companion equipment for this blown arc lamp, can be located at any desired distance from the lamp and the power adjusted remotely by means of a control on the lamp instrument panel.

A paper describing the construction and design of lamps employing the blown-arc principle is scheduled for presentation at the 83d Convention by Russell Ayling and Arthur J. Hatch of the Strong Electric Corp. A demonstration truck will be in Los Angeles during the Convention and a special exhibit is planned for Thursday, April 24, following the evening Session. The demonstration will take place at a large drive-in theater in the Los Angeles area.

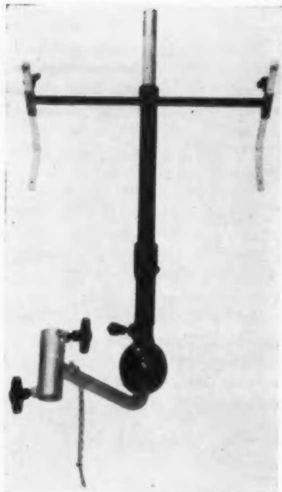
A magnetic film recorder/reproducer designed especially for master recording and re-recording, in the field or studio, has been announced by Stancil-Hoffman Corp., 921 N. Highland Ave., Hollywood 38. The recorder, Model S7, features a large single film sprocket coupled to the drive system through a magnetic clutch. This permits a free-wheeling sprocket for high-speed forward and high-speed rewind while threaded, while providing a positive lock when the clutch is engaged. A selector switch is provided for "A" and "B" film wind. High-speed automatic rewind is available, arranged so that dynamic braking is applied to the reels upon completion of the rewind cycle to prevent film spillage.

Switches located in the tight loop section automatically disconnect the magnetic



clutch and torque motors when the reel ends or if the film should break. The same switches operate a "ready" light which indicates on the unit and at a remote location that the film is properly threaded. A knob adjustment is available on the front panel to c the stabilizer arms for the most effec filtering. The switching is handled by a single bar knob control. One position is designated as "Thread' which applies a dynamic braking to both torque motors. In the "Cue" position, both torque motors are energized and the film sprocket is "free-wheeling." The film sprocket may then be rotated by hand or torque-motor driven for fast forward and rewind "start-mark" location. In the "Ready" position the required take-up and supply voltages are applied to the torque motors and the magnetic clutch is locked. All operations may be remotely controlled from a console position. The master recorder and dummies may be driven by their synchronous motors and/or interlock motors. The synchronous motors have reserve power to drive 16mm projectors through interlock, eliminating the need for a motor distributor system. For large 35mm installations, motor distributors are available as accessory equipment to handle ten or more slave units and projectors. Electronic sections available for single- and multitrack applications may be of vacuum tube or transistor design. The unit is priced at $2350.00.

An automatic graphic high-speed power level recorder, designated Model SL-2, is a product of Sound Apparatus Co., Stirling, N.J. The instrument performs basically the function of a vacuum tube voltmeter and in addition produces a permanent record of the measurement under investigation. It is designed particularly for acoustical and electroacoustical measurements with special reference to reverberation, sound intensity, vibration, sound decay measurements, frequency-response measurements of microphones, loudspeakers, filters and other impulses or phenomena that can be converted into an electrical signal. The recorder features electronically controlled writing speed, push-button operated chart movement and provision for mechanical and electronic connection to associated apparatus.



An adjustable set wall arm called the Type 1731 Junior Trombone is a product of Mole-Richardson Co., 937 North Sycamore Ave., Hollywood 38. The 11-lb wall arm allows for hanging over wall thicknesses of from 2 to 12 in. A Junior lamp may be hung either top or bottom in the socket provided at the end of the swinging arm. Two extensions allow for placing the lamp from 21 to 61 in. from the set wall top and a soft rubber ball prevents damage to the set wall. A safety chain with cotter pin provides extra protection when the lamp is hung from the bottom of the swinging arm.

A high-speed electrical eraser announced by Radio Corp. of America is designed to remove magnetically recorded sound or pictures from a complete reel of tape or film within 30 sec. The unit consists of an automatic turntable on a sliding carriage which transports the tape or film into a large air-core erasing coil mounted on one end of the instrument. The erasing is produced by automatic rotation of the tape or film reel inside a strong alternating magnetic field generated by a 60-cycle current passing through the coil. The effect is to neutralize or "wipe off" all magnetic traces from the tape which can then be used for recording fresh material. Dimensions of the eraser are: 48 in. long, 22½ in. wide and 15 in. high.

Available in two models, video (MI-10891-H) and audio (MI-10891-F), the machine is designed to provide 30-sec erasing of 4800 ft of video magnetic tape up to 2 in. wide; 2400 ft of 6mm film; 2000 ft of 35mm film wound on a film core, or any narrow-width film or tape in rolls up to a maximum of 15 in. in diameter. Each model is priced at $1375.00. Further information is available at the Film Departments of RCA at 411 Fifth Ave., New York 16; and 1016 N. Sycamore, Hollywood 38.

Prestoseal splicers are now handled exclusively for export by Reeves Equipment Corp., 10 E. 52 St., New York 22. The manufacturer is Prestoseal Mfg. Corp., 3727 33 St., Long Island City 1, N.Y. The company designs and manufactures splicing equipment for motion-picture film, magnetic tape and microfilm.

Three new sound-synchronizing kits for adapting the Kodak Pageant Magnetic-Optical Sound Projector for lip-synchronized sound recording have been announced by Cine-Kodak Equipment Sales, Eastman Kodak Co., Rochester 4, N.Y. The kits include the Synchronous Motor Kit; 2-Projector Synchronizing Kit and Synchronizing Brake Kit. The Brake Kit provides for on-set recording of sound effects and dialogue in synchronization with the taking camera. It consists of a nylon spool and a braking strap which permits the projector to be set at a recording speed of precisely 24-frames/sec, or sound speed. A rotating stroboscopic pattern on the spool is adjusted by means of the friction braking device until the pattern appears to stand still when viewed under neon or fluorescent light. The projector is then in-sync with the taking pattern. The Synchronous Motor Kit is an automatic version of the manual braking kit and the 2-Projector Kit is designed especially for firms that edit their own films. The Synchronizing Brake Kit is priced at $14.50, the 2-Projector Synchronizing Kit at $42.25 and the Sychronous Motor Kit at $86.75. The development and design of these equipments were described in detail in a paper by Lee T. Askren and Raymond J. Dwyer, "Recording Lip-Synchronized Sound Using a 16mm Magnetic-Optical Sound Projector," in the *Journal* for January 1958.

A newly-developed 114-ft traveling-wave TV transmitting antenna has been announced by Radio Corp. of America. The antenna, which weighs more than 23,000 lb, has been engineered to eliminate all external antenna elements. It features streamlined, slotted-cylinder construction, built-in radiating elements and simplified feed system. The antenna requires no external feed lines and is available with gains from 8 to 18. The first of the commercially available antennae was purchased by Station KGHL-TV, Billings, Mont. The antenna will be mounted on a 417-ft RCA/Ideco tower to provide more than 4,200-ft elevation above sea level.

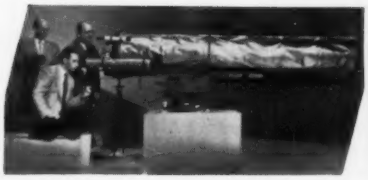
The Lumitron Infinite Preset System is a lighting control system announced by the Lumitron Div., Metropolitan Electric Mfg. Co., 2250 Steinway St., Long Island City 5, N.Y. It consists of electronic digital readers used in conjunction with printed, pre-marked cue cards of the computer-card type. The cue sheet is marked in pen or pencil, depending upon the degree of permanency desired. If desired, circuits may be set up manually so that the cards may be automatically marked by an auxiliary printing device. The notation system consists of digits 1 through 9 and secondary digital adders "1/3" and "2/3." A minimum of two card readers are supplied with each system. Depending on the position of the manual fader, the readers are alternately in "active" or "preview" condition. Custom designed and manufactured to individual specifications, the system is self-contained in a control console. It may be used with any suitable type of power amplifier bank for the control of light intensity, or with any suitable servomechanism for the control of light and color, focus and position.

An Outside Broadcast Television Camera Dolly designed for out-of-studio mobile camera mounting has been introduced by W. Vinten Ltd., London, England. Constructed of steel and aluminum alloy tubes, the dolly has been designed to combine light weight with sturdy construction. A fully compensated steering mechanism allows it to be turned in its own length. The operator's seat assembly can be adjusted for height from 37 in. to 57 in. from the ground. Further information is available from Cinematograph Export Ltd., 715 North Circular Rd., London, N.W.2.

The Cinekad Fishpole Microphone Boom has been announced by Cinekad Engineering Co., 763 Tenth Ave., New York 19. It extends from 6½ to 12 ft, permitting effective microphone placement in situations where a perambulator or stand-mounted boom is unsuitable because of inaccessibility or awkwardness. A monopod feature reduces operator fatigue. A microphone cable is installed inside the boom to eliminate cable noises.

The D. B. Milliken Co., 131 North Fifth St., Arcadia, Calif., has announced two high-speed, intermittent-movement 16mm cameras with pilot-pin registration, suitable for rocket sled and airborne applications. The intermittent movement is designed so that the film is stopped completely during each exposure and locked in place by a register pin. Tested to 100 G's, both models are powered by a 28-v d-c or 115-v a-c motor and operate at two standard speeds, 200 and 400 fps, and are also available for 4, 8, 16, 32, 64, and 128 fps. Dimensions (less lens) of the smaller model, DBM III, are: 6⅜ in. long, 4 in. wide, 5¾ in. high, weighing 6 lb. This model has a 100-ft film capacity. The DBM IV is 7⅞ in. long, 4 in. wide, 5¾ in. high and weighs 7¾ lb. It has a film capacity of 200 ft.

A new type of thin-gauge Mylar polyester film, called 50 Mylar T, has been announced by E. I. du Pont de Nemours & Co., Wilmington, Del. Reported to have almost double the tensile strength of standard Mylar, the new tapes provide 2400 ft of tape on a 7-in. reel. The new tape has the same qualities of resistance to moisture and temperature extremes possessed by the standard tape and is unaffected by lengthy storage. At present the film is available in limited quantities. It is priced at $4.50 per pound.



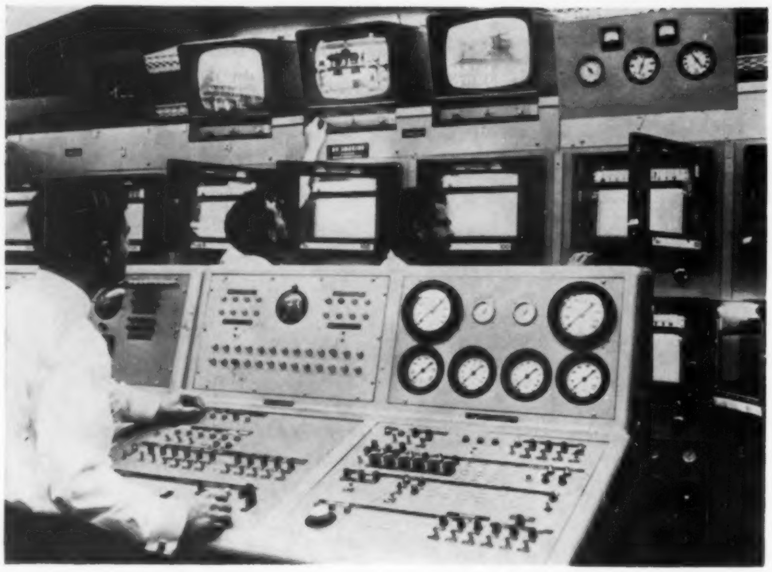
Research in the field of aerial haze penetration has been advanced by the use of a 9-foot-long telecamera designed by Eastman Kodak Co. This research is particularly important to the development of aerial reconnaissance film and cameras. The camera has a 95-in. focal length. The long focal length is possible because of the use of reflector combinations that cause the light from the subject to travel the length of the camera three times. Pictures taken through the camera at a distance of approximately two miles from the subject reveal important data, such as the differences from normal contrast between a black and a white target due to atmospheric haze. Information about aerial haze penetration by visible and infrared radiation has also been obtained through use of the camera.

"Satellite" tape, a magnetic tape manufactured by the Minnesota Mining and Manufacturing Co., 900 Bush St., St. Paul 6, Minn. was developed especially to record data from the IGY earth satellite launched by the Naval Research Laboratory's Vanguard rocket. This tape has also been used to record signals from U.S. Army satellites and Russian Sputniks as part of the International Geophysical Year program. 3M has reported that its Satellite tape production is based on research and development done earlier for video tape which is more difficult to manufacture.

Various sensing devices aboard the satellites measure temperature, surface erosion and other phenomena. The information is recorded on tape which is sent to a computer center in Washington, D.C., for data processing and analysis.

Each of the tapes supplied for the satellites is ½ in. wide and 2500 ft long. It is used to record seven data channels at tape speeds of 30 in./sec on instrumentation-type magnetic tape recorders. The tape has a maroon, high-potency magnetic oxide coated on a 1.5-mil polyester film base to a thickness of 0.35 mil. More than 100 quality control checks are said to go into the production of this tape. When the first Vanguard instrumented satellite was launched, three of the seven channels recorded on tape were expected to be used for recording the telemetered data. Three others were to be used for recording timing information, while the seventh channel was to be held in reserve.

Two of the three data channels record conventionally and linearly detected signals by direct recording methods and the third channel on the tape uses pulse-width recording. Of the three timing channels, one records a precision standard frequency for use in accurate pulse width measurements. The second records in code the time of day at which the recording was made and the third records synchronizing signals for correct synchronization of the tape playback speed.



One of the largest closed-circuit TV systems in the United States is installed at Aerojet-General Corp.'s rocket engine test facility at Sacramento, Calif. The system was manufactured by Hallamore Electronics Co., Anaheim, Calif., a division of Siegler Corp. The $300,000 system is made up of 36 complete camera-receiver chains built to monitor hazardous static rocket firings in the liquid and the solid propellant rocket plants. Features include all-electric camera controls at the viewing site and a two-way, built-in sound system. Technicians in blockhouses situated at safe distances view the static firings on 17-in. screens mounted beside data-recording instruments.

A spray called Krylon Crystal-Clear Acrylic Spray acts as a deterrent to corrosion and pitting of the metal parts of film processors. A product of Krylon Inc., 18 West Airy St., Norristown, Pa., the newly developed spray coats the metal areas with a protective shield that resists the corroding action of photographic chemicals.

The RCA Test and Measuring Equipment Catalog, 2nd ed., contains up-to-date information on the company's line of audio, video, transmitter and general purpose test equipment. The 76-page catalog also includes a discussion of recommended test procedures. It is illustrated and contains diagrams and specifications of the equipment. Published by the Broadcast and Television Equipment Dept. of RCA, Camden, N.J., it is priced at $1.00.

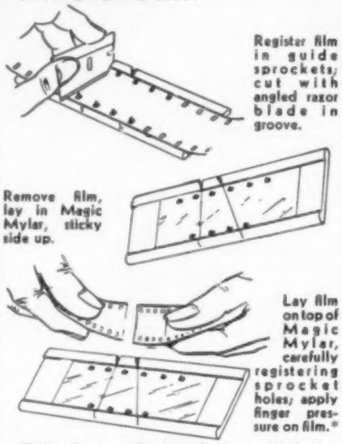
A 16-panel folder called *Which Tape Type Are You?* is available without charge from Minnesota Mining and Mfg. Co. Dept. A8-89, St. Paul, Minn. The folder describes each of eight types of Scotch magnetic tapes with information on playing time, special features, backing thickness and applications. A playing time chart and suggestions on dry lubrication are included.

Howard S. Meighan has announced his resignation as Vice-President of Columbia Broadcasting System to accept the post of Special Consultant to Ampex Corp. He also announced formation of two companies to produce video tape commercials. He is associated in this venture with Ampex Corp. The two companies are Video Tape Productions of New York, Inc., New York; and Video Tape Productions of California Inc., Hollywood. A third company, to be known as Video Tape Productions Midwest Inc., is being planned.

Products described in data sheets issued by Traid Corp., 17136 Ventura Blvd., Encino, Calif., include the No. 652 Correlation Counter which correlates film records from many separate cameras; the No. 450 Fotoscope for photographing cathode-ray tube and auxiliary data; and photo-periscopes developed by Zoomar Inc. The data sheets are published as supplements to the company's publication, *Traid Winds*, which has recently been issued in a larger format.

F&B BUTT SPLICING BLOCKS

Now . . . a new, amazingly simple device for butt-splicing 16mm and 35mm film with Magic Mylar. Simple as A-B-C . . . !

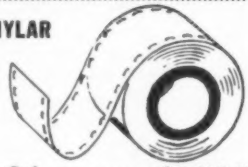


That's all . . . the Butt Splice is finished! (*For double strength, Magic Mylar may be placed on both sides of film.)

Model B-16 for 16mm	$ 9.50
Model B-35 for 35mm	11.50
Model B-4 for ¼" magnetic tape	6.50
Model B5B comb. unit for 16/35mm and ¼" magnetic tape	24.50

MAGIC MYLAR

Transparent Sprocketed Splicing Tape



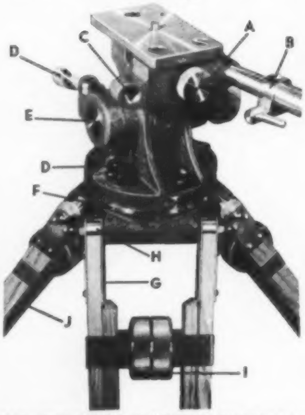
16mm—Single Perf	$ 5.00 Roll
16mm—Double Perf	$ 5.00 Roll
35mm	$ 9.00 Roll

OPAQUE—FOR MAGNETIC FILM

16mm	$ 6.60 Roll
35mm	$11.00 Roll

F&B PRO-CINE TRIPOD

MODEL 202



THESE EXCLUSIVE FEATURES ORIGINALLY DESIGNED BY F & B

A.—Camera tightening knob-angle gears.
B.—Telescoping, offset pan handle.
C.—Second pan handle position.
D.—Large pan and tilt tension locks.
E.—Large diameter precision center shaft.
F.—Precision machined friction plate.
G.—Leg brackets firmly bolted with leg rest ledge.
H.—Aluminum leg tops.
I.—Single leg locking knobs— prevents bending & warping.
J.—Superb, seasoned, oil-treated hardwood legs.

NEW LOW PRICE $120.00

FLORMAN & BABB, INC.
68 West 45th St., New York, N. Y.

Professional Services

APPRAISALS OF FILM PRODUCTION EQUIP.
Cameras, Lenses, Lights, Recorders, Cutting Rooms, Laboratories, Printers, Processors, etc. 32 years background, gilt-edged references, assure acceptance by banks, Small Business Administration. Confidential, fees reasonable. Appraisers, Room 610, 147 W. 42nd St., New York 36. Phone: PLaza 7-5121.

BERTIL I. CARLSON
Photoproducts Co.
Consultants, designers, builders in PHOTO INSTRUMENTATION
Color Processors • Cameras • Projectors
Box 60, Fort Lee, N. J.

CRITERION
FILM LABORATORIES, INC.
Complete laboratory facilities for 16 & 35mm black-and-white and color
33 West 60th St., New York 23, N. Y.
Phone: COlumbus 5-2180

ELLIS W. D'ARCY & ASSOCIATES
Consulting and Development Engineers
Xenon-Arc Applications
Motion-Picture Projection
Magnetic Recording and Reproduction
Box 1103, Ogden Dunes, Gary, Ind.
Phone: Twin Oaks 5-4201

EAGLE FILM LABORATORY, INC.
(Established 1951)
A 16MM SPECIALIST LABORATORY
341 E. Ohio St., Chicago 11, Ill.
WHitehall 4-2295

FISCHER PHOTOGRAPHIC LABORATORY, INC.
EUclid 6-6603
6555 North Ave., Oak Park, Ill.

RENT
16mm, 35mm, 70mm
Motion Picture Cameras
High Speed Cameras
Special Cameras
Lenses
Lights
Processing Equipment
Editing Equipment
GORDON ENTERPRISES
5362 N. Cahuenga, North Hollywood, Calif.

MITCHELL CAMERAS
Studio—Industry—Science—Research
16mm—35mm—65mm and Accessories
For Demonstrations Visit Our Showroom and Offices
For Technical Information and Brochures Write
MITCHELL CAMERA OF NEW YORK, INC.
521 Fifth Ave., New York 17, N. Y. Oxford 7-0227

COLORTRAN CONVERTER LIGHTING EQUIPMENT
The most illumination for the least investment
CROSS COUNTRY RENTAL SYSTEM ELIMINATES COSTLY SHIPPING
write for catalog
NATURAL LIGHTING CORP.
612 W. Elk, Glendale 4, Calif.

PHOTOGRAPHIC INSTRUMENTATION
Specializing in
HIGH-SPEED
Motion-Picture Photography
Photographic Analysis Company
100 Rock Hill Rd., Clifton, N. J.
Phone: Prescott 8-6436

PROFESSIONAL MOTION PICTURE PRODUCTION EQUIPMENT
Cameras, Sound Recording, Editing, Laboratory and Affiliated Equip.
Consulting Services by Qualified Engineers
Domestic and Foreign
REEVES EQUIPMENT CORP.
10 E. 52nd St., NYC
Cable: REEVESQUIP

SUPPLIERS PHOTOGRAPHIC CHEMICALS
and
Consultants in Photographic Chemistry
L. B. Russell Chemicals, Inc.
14-33 Thirty-First Avenue
Long Island City 6, New York
YEllowstone 2-8500

SLIDE-FILM LAB
USE A SPECIALIST!
We specialize in color filmstrip work:
(1) Shooting masters
(2) Release prints
Contract rates available
CUSTOM FILM LAB
CIrcle 5-4830 1780 Broadway, N.Y. 19, N.Y.

WILLIAM B. SNOW
Consulting Engineer
STUDIO ACOUSTICS
NOISE CONTROL
1011 Georgina Avenue
Santa Monica, California
EXbrook 4-8345

FILM PRODUCTION EQUIP.
The world's largest source of supply for practically every need for producing, processing, recording and editing motion picture films.
Domestic and Foreign
S.O.S. CINEMA SUPPLY CORP.
Dept. TE, 602 W. 52 St., N.Y.C.-Cable: SOSOUND
Western Branch: 6331 Holly'd Blvd., Holly'd, Cal.

ROCKY MOUNTAIN HEADQUARTERS
For 16mm Film Services
B&W and Anscochrome Processing
Printing—Recording—Editing
Production—Rental—Sales
All types of film in stock
Write for Price List
WESTERN CINE SERVICE, INC.
114 E. 8th Ave., Denver 3, Colo. TAbor 5-2812

Professional cards available to members

12 insertions, 2x1 in., $60

employment service

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Top Animation Cameraman and technician with over 10 yr experience and 3000 commercial or show direction and production credits, desires position with live studio or TV station. Have own equipment including servo-automatic animation stand, adapted Mitchell 35mm camera, 35mm optical and magnetic recording equipment, rotoscopes, 3-D cameras, complete machine shop, still equipment. Experience as mixer, live cameraman, TV camera editor, art director, puppets, color processor, machinist, set construction, etc. Will relocate anywhere throughout the world. Write: Animated Commercials, Inc., 451 West 50 St., New York 19.

Engineering Photographer. B.S. degree. Twenty years professional experience. Last ten years in two large research organizations, director of photo section for several years. Experience includes commercial and industrial photography, high-speed cinematography, schlieren, 16mm motion pictures. Desires position with opportunity and challenge. Will relocate. Résumé and references on request. Write: Simeon Braunstein, 2666 Valentine Ave., New York 58.

Cameraman-Editor and Production Man experienced in educational and documentary work in Japan, Near East and U.S. Currently independent producer of community problem films but interested in camera work and challenging productions anywhere. Extensive film editing and writing background. Own 16mm equipment. Speak several languages; graduate work abroad in anthropology. Age 29, vet and single. Richard Cressey, 101 Windsor Place, Syracuse 10, N.Y.

Motion-Picture Production. Film student currently studying film at Institute of Film Techniques evenings, wishes full-time job in production, preferably in New York area. Recently finished 2-hr film at amusement park in N.J.; now working on experimental color film using animation. Energetic, with knowledge of many phases of film production; main interest and ambitions are in cinematography. Own 16mm equipment. Write: Leonard DeMunde, 534 Tillman St., Hillside 5, N.J.

Motion Pictures. Argentine, age 43, married, relocating permanently in U. S., seeks position with opportunity for advancement, preferably in California. 23 yr experience in photography, 12 yr teaching at government school; head of motion-picture dept. of local engineering college; familiar with most technical problems; lineal drawing; degree in optics; writer for photog. magazines; workable knowledge English language. Would prefer work in color labs, but would consider other positions. For details inquire: Juan Esnaola, 90 Font, 111 W. 94th St., New York 25.

Plant Photographer, Educational TV Broadcasting, Technical Representative. Extensive background in teaching and training TV studio personnel. Twelve years experience in TV and commercial photography. Owned and operated studio with commercial accounts. Veteran, age 33, married. Résumé and references on request. Al Victor, 150-11 14th Ave., Whitestone (57), N. Y. Tel: INdependence 1-2881.

Engineer-Photographic. Extensive experience in design and development of military and consumer opto-electromechanical photographic products and instrumentation. Capable of assuming complete responsibility from creative inception to acceptable prototype. Experience in manufacturing procedures, design simplicity and parts interchangeability. Seeking project assignment or part-time engagement. Foto, 495 Hempstead Turnpike, W. Hempstead, N. Y.

MP-TV Production or Direction Assistant. Young man, recent graduate in Communication Arts at New York University, desires position in motion-picture or television production with active film company or TV station. Job must have a future. Age 24, married; vet, willing to relocate. Complete résumé on request. Nat Gold, 325 East 194 St., Bronx, N.Y.

Administrative Engineer. The SMPTE's former Staff Engineer, Henry Kogel, is seeking a new position, after 6 years working with SMPTE Engineering Committees and the motion-picture standards program; also serving as Secy, American Standards Assn. Sec. Committee PH22, and Tech. Secy, International Standardization Orgn. Tech. Com. 36, Cinematography; 2 years, previously, develop. engr. with Sperry Gyroscope Co.; B.S. Elec. Eng., Columbia Univ., 1948, after military service as radio off.; recently sales engineer with Century Lighting Inc.; age 38; married; complete résumé upon request. Henry Kogel, 19–24 202 St., Bayside 60, N.Y.; Tel. BAyside 9-3574.

Optical Effects Company owner and operator seeks change. Over 8 years experience in opticals and effects work. Familiar with all phases of processing, editing and production. Have also worked as motion picture theatre manager. Willing to relocate. B.A. in Business Administration. Age 32. Reply to: Occupant, Apt. B-32, 796 Bronx River Rd., Bronxville, N.Y.

Motion-Picture Production. Experienced in film production, studio and location, educational, industrial and TV films; some editing; extensive theatre and writing background; former CCNY Dept. of Speech lecturer; degrees in drama and journalism. Seeking permanent production assignment with production-direction future. Willing to relocate. Age 29. Résumé on request. Write: S. M. Syna, 24 East 97 St., New York. Tel: TE 1-0444.

Motion-Picture Production. Present Director of Motion-Picture Operations at a leading Southeastern University is seeking a position as production executive with a commercial motion-picture operation. College education in fields of Industrial Engineering and Speech, in addition to motion-picture and television production. Experienced in the various phases of film production, as well as labor-management relations. CAA pilot's certificate, member of SMPTE and University Film Producers Association. Complete résumé on request. Excellent references. If you need a production executive with imagination, contact: Duane K. Wacker, 2050 N.W. 7th Place, Gainesville, Fla.

Positions Available

Mechanical-Optical Engineer. Must have M.E. background with extensive and intimate knowledge of long focal length optics. Work will involve evaluation and improvement of large tracking telescopes and other optical systems used in missile range instrumentation. Applicants should have the educational and experience background to assume heavy project responsibilities. Salary commensurate with capability, plus outstanding bonus arrangement. Positions are located at Air Force Missile Development Center, Holloman, New Mexico, 10 miles southwest of Alamogordo, N.M. Contact W. F. Goodwin, Personnel Administrator, Land-Air, Inc., Box 394, Holloman, N.M.

Contents — pages 264 - 288

News Columns

Advertisers

Meeting Calendar

Electrochemical Society, Apr. 27–May 1, Statler Hotel, New York.

National Academy of Sciences, Annual Meeting, Apr. 28–30, Washington, D. C.

NAB, 36th Annual Convention, Apr. 28–May 1, Biltmore & Statler Hotels, Los Angeles.

Professional Group on Microwave Theory and Techniques, National Symposium, May 5–7, Stanford U., Stanford, Calif.

Acoustical Society of America, Spring Meeting, May 7–9, Washington, D. C.

Society of American Military Engineers, 38th Annual Meeting, May 20–21, Washington, D. C.

Conference on Use of Films by Business and Industry, May 27–29, at the Univ. of California Extension Center, San Francisco, presented by San Francisco Film Producers Assn., Dept of Journalism and School of Business Administration at the Univ. of California, Berkeley and University Extension. Enrollment fee, $40. For further information write Dept. of Conferences and Special Activities, Univ. of California Extension, 2441 Bancroft Way, Berkeley, Calif.

Armed Forces Communications and Electronics Association, National Convention, June 4–6, Sheraton Park Hotel, Washington, D. C.

International Standardization Organization, Comm. 43 Acoustics, July 14–18, Stockholm, Sweden.

National Audio-Visual Association, Annual Convention, July 26–29, Morrison Hotel, Chicago.

Biological Photographic Assn., Aug. 18–21, at the Shoreham Hotel in Washington, D. C. Will feature award-winning display of transparencies, prints and motion pictures.

WESCON, Aug. 19–22, Ambassador Hotel, Los Angeles.

Fourth International Congress on High-Speed Photography, including Equipment Exhibit, Sept. 22–27, Cologne.

Society of Photographic Scientists and Engineers, Annual Technical Conference, Oct. 6–10, Manger Rochester Hotel, Rochester, N.Y.

Optical Society of America, Oct. 9–11, Hotel Statler, Detroit, Mich.

National Electronics Conference, Oct. 13–15, Hotel Sherman, Chicago.

84th Semiannual Convention of the SMPTE, Oct. 20–24, Sheraton-Cadillac, Detroit.

American Standards Association, Ninth National Conference on Standards, Nov. 18–20, Hotel Roosevelt, New York.

Acoustical Society of America, Nov. 21–23, Chicago, Ill.

85th Semiannual Convention of the SMPTE, including International Equipment Exhibit, May 4–8, 1959, Fontainebleau, Miami Beach.

86th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 5–9, 1959, Statler, New York.

87th Semiannual Convention of the SMPTE, May 1–7, 1960, Ambassador Hotel, Los Angeles

88th Semiannual Convention of the SMPTE, Fall, 1960, Shoreham Hotel, Washington, D C.

89th Semiannual Convention of the SMPTE, Spring, 1961, Royal York, Toronto.

90th Semiannual Convention of the SMPTE, Oct. 15-20, 1961, Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members appear in Part II of this Journal.

sustaining members

of the Society of Motion Picture and Television Engineers

Acme Film Laboratories, Inc.
Alexander Film Co.
Altec Companies
Ampex Corporation
Animation Equipment Corp.
Ansco
C. S. Ashcraft Mfg. Co.
Atlas Film Corporation
Audio Productions, Inc.
The Ballantyne Company
Bausch & Lomb Optical Co.
Bell & Howell Company
Berndt-Bach, Inc.
Burnett-Timken Research Laboratory
Byron, Inc.
CBS Television
  Terrytoons, Inc.
The Calvin Company
Capital Film Laboratories, Inc.
Oscar F. Carlson Company
Century Lighting, Inc.
Century Projector Corporation
Cineffects, Inc.
Cinema-Tirage L. Maurice
Geo. W. Colburn Laboratory, Inc.
Comprehensive Service Corporation
Consolidated Film Industries
The Daven Company
Andre Debrie Mfg. Corp.
DeFrenes Company
DeLuxe Laboratories, Inc.
Desilu Productions, Inc.
Dominion Sound Equipments Limited
Du Art Laboratories, Inc.
E. I. du Pont de Nemours & Co , Inc.
Dynamic Films, Inc.
Eastman Kodak Company
Elgeet Optical Company, Inc.
Max Factor & Co.
Fordel Films, Inc.
General Electric Company
General Film Laboratories Corporation
General Motors Photographic
General Precision Equipment Corp.
  General Precision Laboratory Incorporated
  Graflex, Inc.
  The Hertner Electric Company
  National Theatre Supply
  The Strong Electric Company
W. J. German, Inc.
Guffanti Film Laboratories, Inc.
Frank Herrnfeld Eng. Corp.
Hollywood Film Company
Hollywood Film Enterprises Laboratory
Houston Fearless
Hunt's Theatres
JM Developments, Inc.
The Jam Handy Organization, Inc.
Jamieson Film Co.
Kalart Co.
KINTEL (Kay Lab)
Kling Photo Corp. (ARRI Div.)
Kollmorgen Optical Corporation
Lorraine Carbons
J. A. Maurer, Inc.
  Precision Film Laboratories, Inc.
Mecca Film Laboratories, Inc.
Mitchell Camera Corporation
Mole-Richardson Co.
Motiograph, Inc.
Motion Picture Association of America, Inc.
  Allied Artists Products, Inc.
  Columbia Pictures Corporation
  Loew's Inc.
  Paramount Pictures Corporation
  RKO Radio Pictures, Inc.
  Twentieth Century-Fox Film Corp.
  United Artists Corporation
  Universal Pictures Company, Inc.
  Warner Bros. Pictures, Inc.
Motion Picture Printing Equipment Co.
Movielab Film Laboratories, Inc.
Moviola Manufacturing Co.
National Carbon Company, A Division of Union Carbide and Carbon Corporation
National Screen Service Corporation
National Theatre Amusement Co.
Neighborhood Theatre, Inc.
Neumade Products Corp.
Northwest Sound Service, Inc.
Panavision Incorporated
Pathé Laboratories, Inc.
Prestoseal Mfg. Corp.
Producers Service Co.
Radiant Manufacturing Corporation
Radio Corporation of America
Reid H. Ray Film Industries, Inc.
Reeves Sound Studios, Inc.
Charles Ross, Inc.
S.O.S. Cinema Supply Corp.
Shelly Films Limited (Canada)
Technicolor Corporation
Titra Film Laboratories, Inc.
Trans-Canada Films Ltd.
Van Praag Productions
Victor Animatograph Corp.
Alexander F. Victor Enterprises, Inc.
Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
Wollensak Optical Company